COST-EFFECTIVE TECHNIQUES FOR IMPROVED OIL RECOVERY IN MISSISSIPPIAN CARBONATE RESERVOIRS OF KANSAS -- NEAR TERM -- CLASS 2

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DOE PROJECT MANAGER: Daniel J. Ferguson (dferguso@npto.doe.gov; 918.699.2047)
CONTRACT PERFORMANCE PERIOD: 9/16/1994 to 1/31/2000

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The majority of Kansas production is operated by the small independent oil and gas producer (90% of the 3,000 Kansas producers have less than 20 employees). The independent producer does not have the extensive resources and the ready access to a research lab to develop and test advanced technologies. For the Kansas oil and gas industry, access to new technology remains a critical component to sustained production and increased economic viability. A major emphasis of the Kansas Class 2 project was collaboration of University of Kansas scientists and engineers with Kansas independent producers and service companies. The goal was to develop and modify cost-effective new technologies and to accelerate adaptation and evaluation of these technologies.

The project introduced a number of potentially useful technologies, and demonstrated these technologies in actual oil field operations. Advanced technology was tailored specifically to the scale appropriate to the operations of Kansas producers. An extensive technology transfer effort is ongoing. Traditional technology transfer methods (e.g., publications and workshops) were supplemented with a public domain relational database and online package of project results is available through the Internet. The goal is to provide the independent complete access to project data and technology on the desktop.

Project Background

The demonstration project was conducted in cooperation with Ritchie Exploration, Inc. of Wichita, which operates leases that were the focus of the demonstration. However, a number of major operators in the Schaben Field contributed data to the project, and tested and adopted project results. Schaben Field (1963 discovery) is located in Ness County on the western flank of the Central Kansas uplift, and is typical of Mississippian production in Kansas. Prior to project initiation, cumulative field production was 9.1 million barrels of oil, and daily production was 326 BOPD from 51 wells prior. In Kansas, the majority of Mississippian production occurs at or near the top just below a regional unconformity. Production from Mississippian reservoirs accounts for approximately 43% of total annual production, and cumulative production exceeds 1 billion barrels. Today, independent producers, operating many of these reservoirs and production units, deal with high water cuts and low recovery factors that place continued operations at or near economic limits.

Cost Effective Technology for Independent Producers

Common problems in Kansas reservoirs that affect producibility include; old and missing data, inadequate reservoir characterization, drilling and completion design problems, and non-optimal primary

recovery. The value of cost-effective techniques for reservoir characterization and simulation at Schaben Field were demonstrated to independent operators. All major operators at Schaben have used results of the reservoir management strategy to locate and drill additional infill locations. At the Schaben Demonstration Site, the additional locations resulted in incremental production increases of 200 BOPD from a smaller number of wells.

Integrated geologic reservoir characterization provided the basis for development of a quantitative reservoir model. Descriptive reservoir characterization entailed integration and creative application of existing vintage data, drilling and coring three new wells. Core analysis (including NMR), petrophysical analysis, calibration of logs and core data were integrated with existing well data into a computerized 3D visualization. Procedures and computer code were developed to modify, load and display well logs using seismic workstations for improved 3D visualization using available wireline log data. Geologic, engineering and production data were brought into a common set of relational databases. Much of the data from Schaben Field is available on-line at reservoir, lease and well levels.

Log and core analyses, and petrographic descriptions were completed to better understand the pore geometry of the carbonate reservoir. All of the complexities existing in an evaluation of an extremely heterogeneous reservoir are present in the producing reservoir at Schaben Field. Determination of pore size, throat size, irreducible water saturation, permeability, effective porosity, and movable oil was possible using cost-effective techniques on existing data. As an example, NMR and capillary pressure data on 18 core plugs were used to determine fluid filled porosity, free fluid porosity, bound water porosity, pore size, grainsize, and irreducible water saturation. One aspect of the project involved development of a low-cost PC-based petrophysical analysis package (PfEFFER). The program, available to oil operators works as part of a spreadsheet, and is a practical tool for the real-time, interactive log analysis. Spreadsheet database and graphic features allow both rapid interaction and comparative evaluation of multiple interpretations or best case/worst case extremes. A project file manages multiple wells and zones, and can be generated that assembles reservoir parameter, grids them, and displays them as 2-D maps or 3-D surfaces. After completion of the reservoir characterization, the US DOE Boast 3 Reservoir Simulation Package was adapted for use at the full-field scale. The Boast Freeware was modified to work with commonly available, spreadsheet programs as pre- and post-processors. The result was a full field reservoir simulation model and management tool that the independent producer can run on a desktop PC using freeware and a spreadsheet.

Project design, methodologies, data, and results are disseminated to independent operators through focused technology transfer activities. These activities include development of cost-effective technologies (e.g. PFEFFER, "Pseudoseismic"), traditional publication; workshops and seminars; and public access through the Internet. In addition to traditional workshops, electronic courses covering important technologies are available on the North Mid-continent PTTC Internet Site. The target audience includes other operators in the demonstration area, operators of numerous other Mississippian sub-unconformity dolomite reservoirs in Kansas, operators of analogous shallow shelf carbonate reservoirs in the Mid-continent and technical personnel with reservoir development and management.

Summary

All technologies used have been adapted to be cost-effective for independent operators of mature fields. Technologies include petrophysical analysis (PfEFFER), visualization (Pseudoseismic), core analysis using NMR, numerical simulation on a PC, and Internet technology transfer. The value of these technologies for independent operators has been demonstrated. All major operators at Schaben have adopted the results of the reservoir management strategy developed as part of the study, and have located and drilled approximately 20 infill locations. Overall results of the incremental wells are very favorable. The procedures continued to be transferred to other independent operators through publication, presentations, hands-on computer workshops and Internet access.

Improved Oil Recovery in Mississippian Carbonate Reservoirs of Kansas

Appropriate Advanced Technology

for the

Independent Producer

Participants

Ritchie Exploration Inc., Wichita Kansas

ERC

Kansas Geological Survey

T.O.R.P.

United States Department of Energy

Science, Security and Energy: Powering the 21st Century

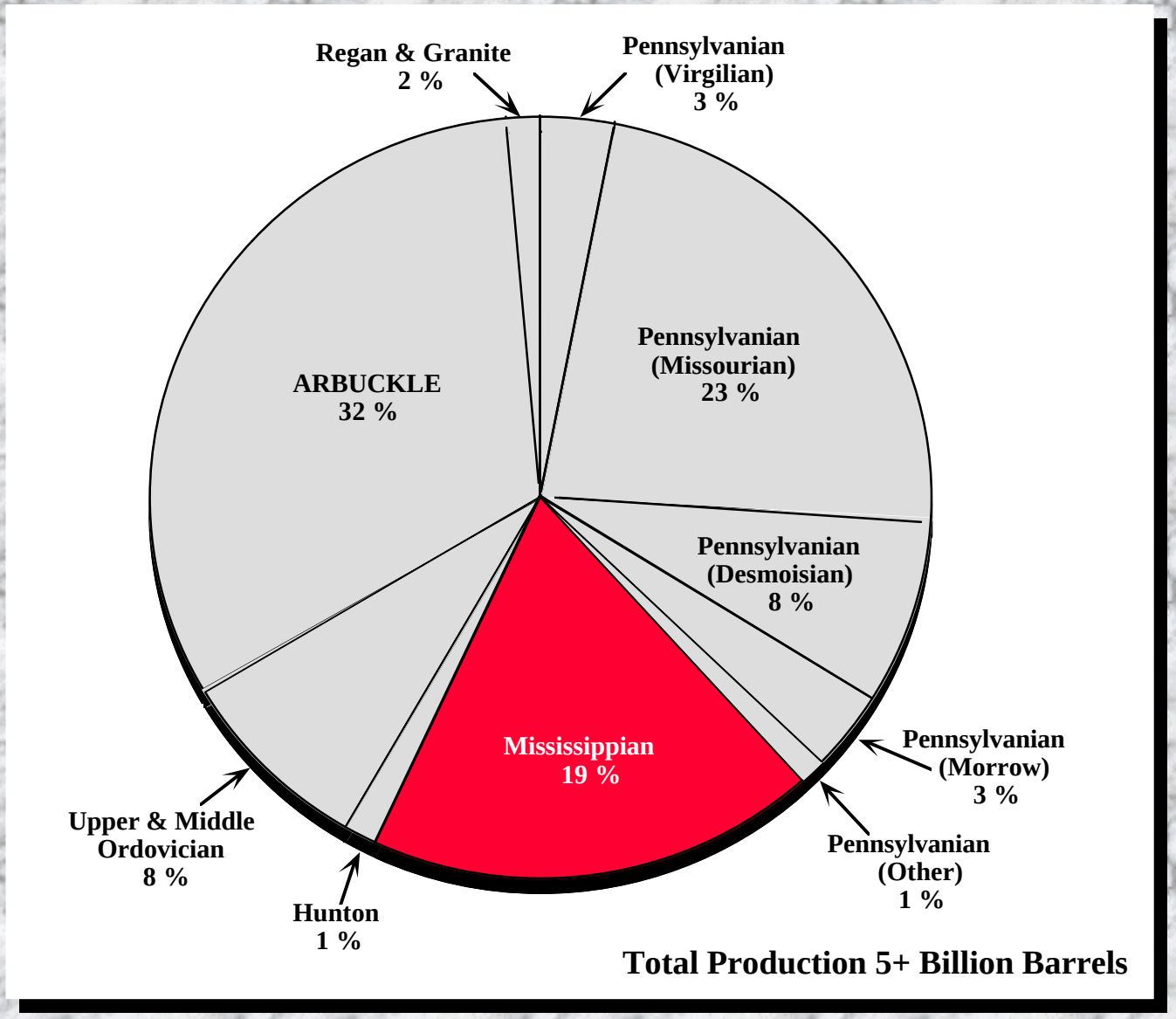
Project Philosophy

- Appropriate Cost-Effective Technology
  - Application to Kansas Fields
  - Develop and Modify
  - Transfer
- Impact a Broad Base of Kansas Production
  - 3,000 Operating Companies
  - Mississippian
    - Cumulative 1 Billion Barrels
    - Producing Oil Wells 17,542

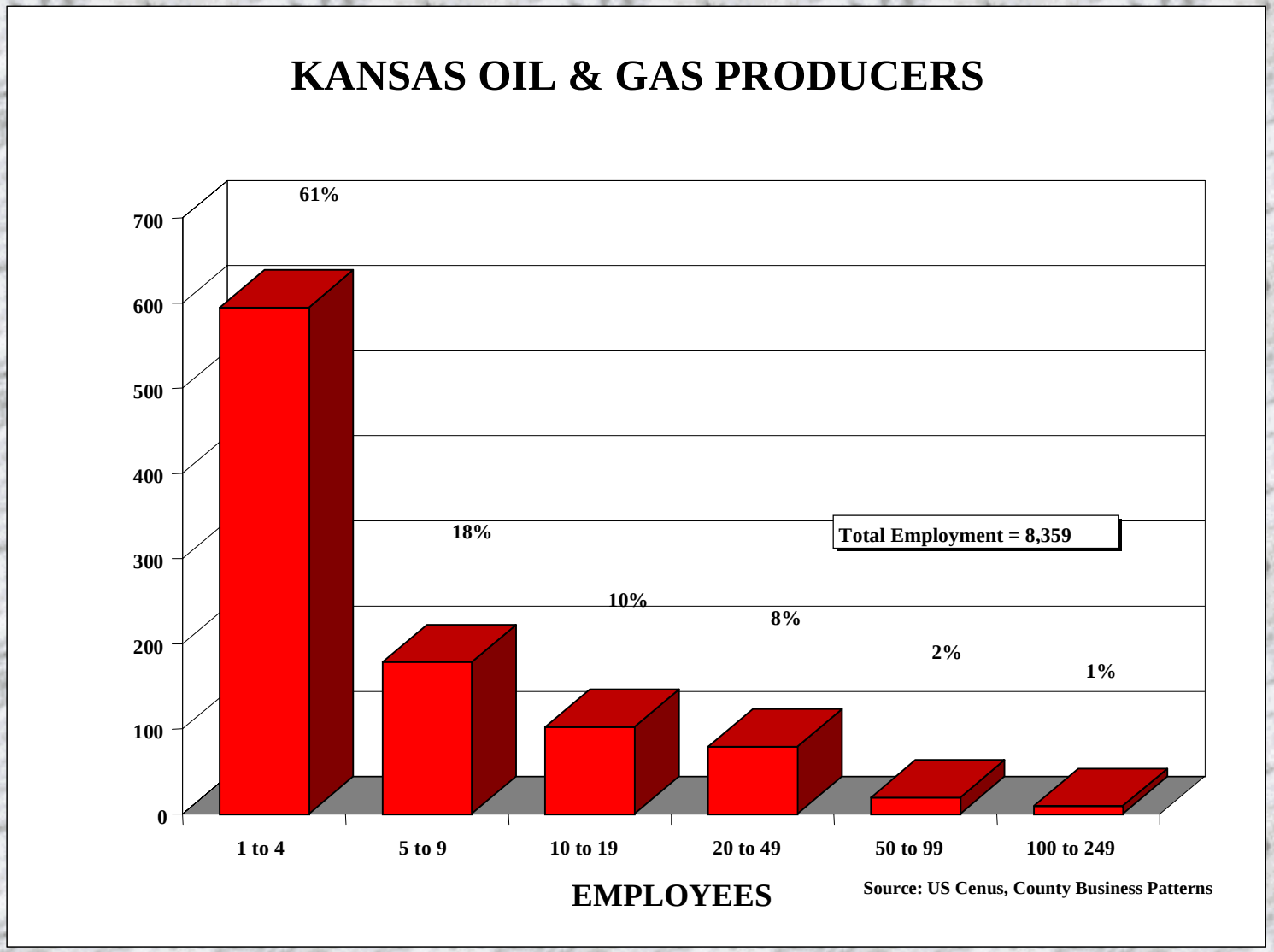
Project Accomplishments

- Cost Effective Technology
  - Visualization
  - Petrophysical Analysis
  - Core Analysis
  - PC based Reservoir Simulation
  - Internet Technology Transfer
- Incremental Oil
  - Additional 200 BOPD

Kansas Oil and Gas Industry



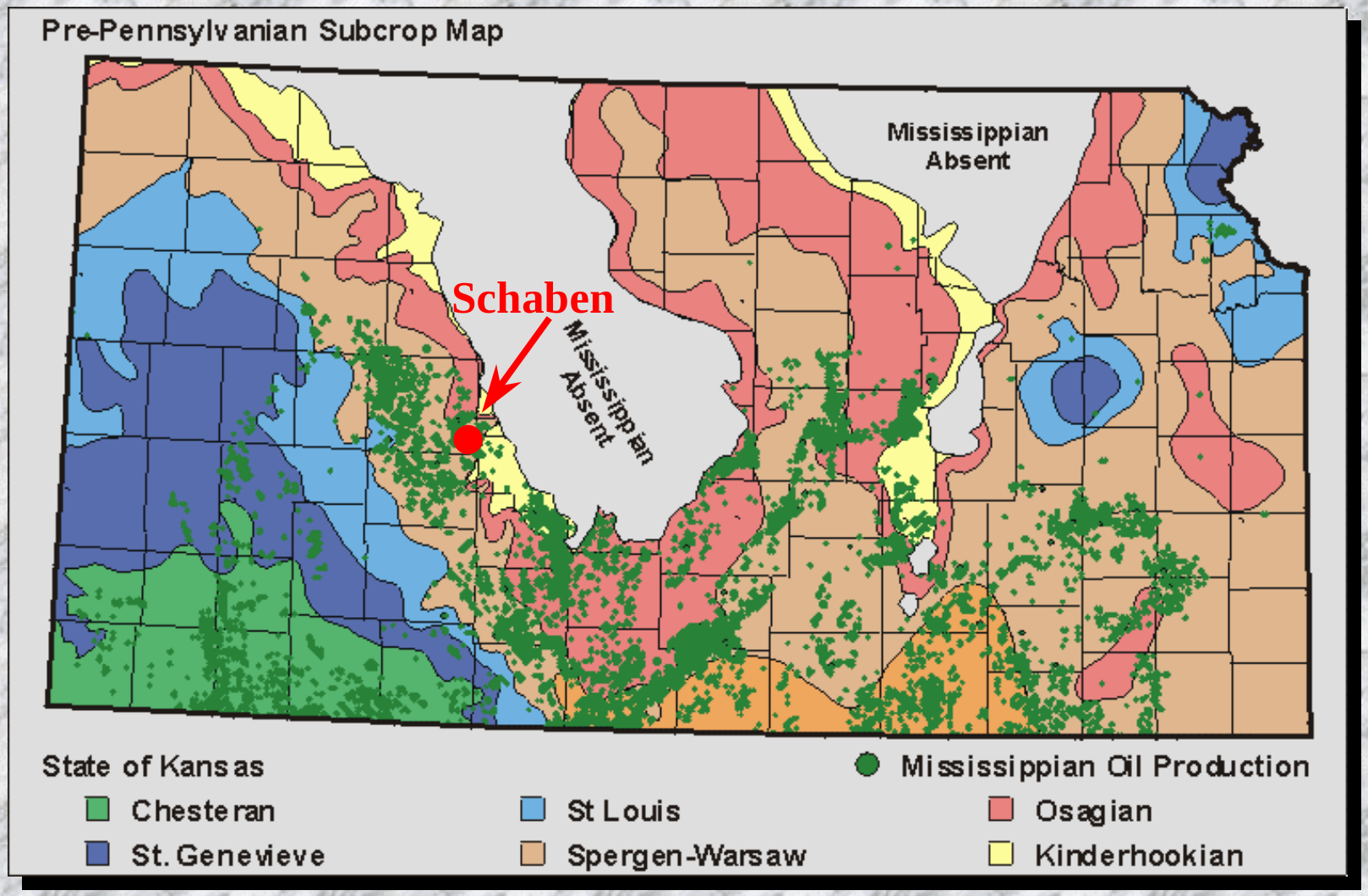
Kansas Oil and Gas Industry



Schaben Field

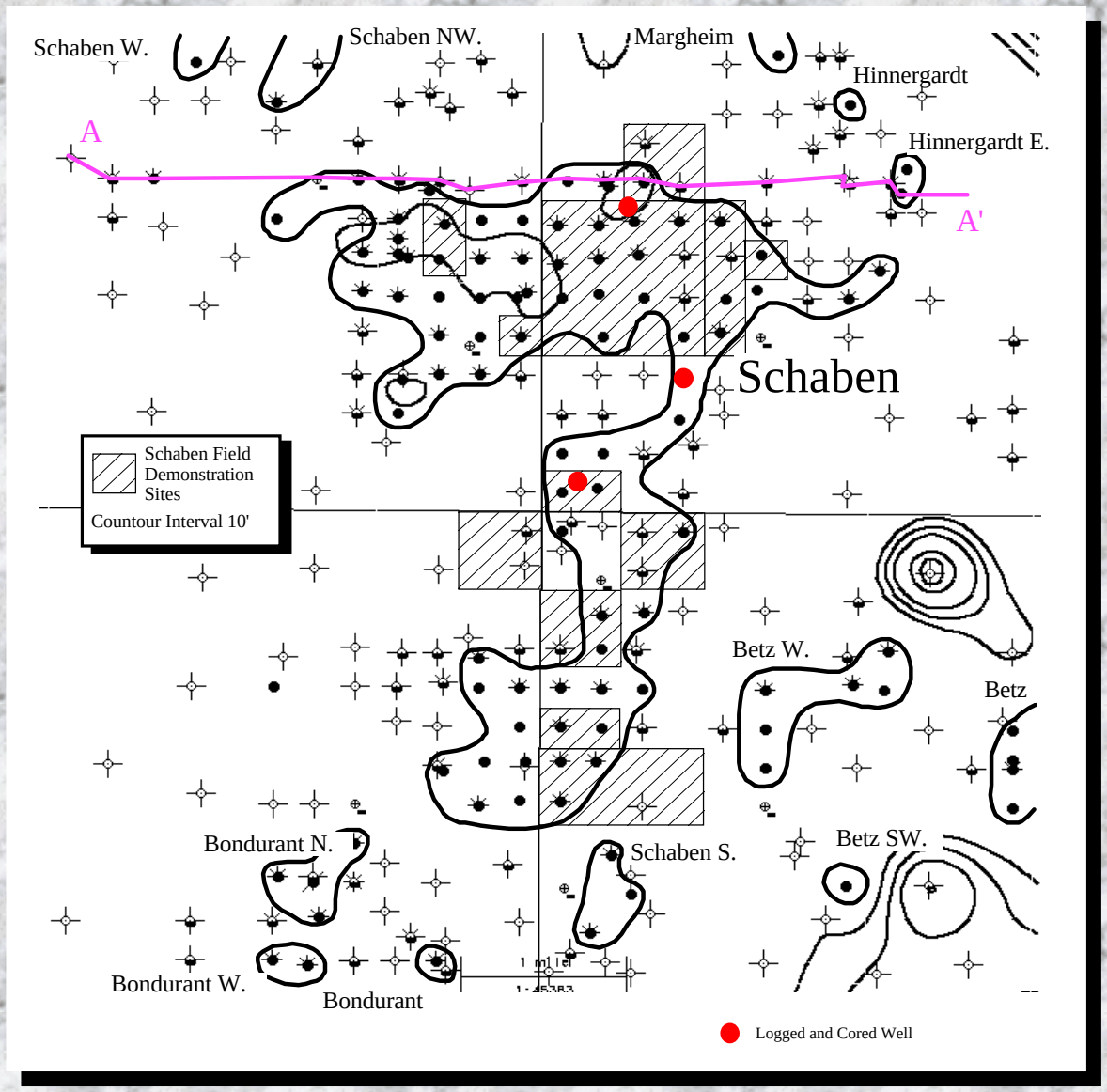
- Discovery Date: October, 1963
- Producing Horizon: Mississippian (Osagian)
- Active Water Drive
- Producing Depth: 4400’
- Cumulative Production: 9.3 MMBO
- Producing Wells: 47 (Oct-98)
- Estimated Field OOIP: 40-50 MMBO
- Average Field Rec. Eff. = 17%

Subcrop Map of Mississippian Rocks of Kansas



http://www.kgs.ukans.edu/DPA/Plays/ProdMaps/miss_sub_oil.html

Schaben Field Demonstration Area

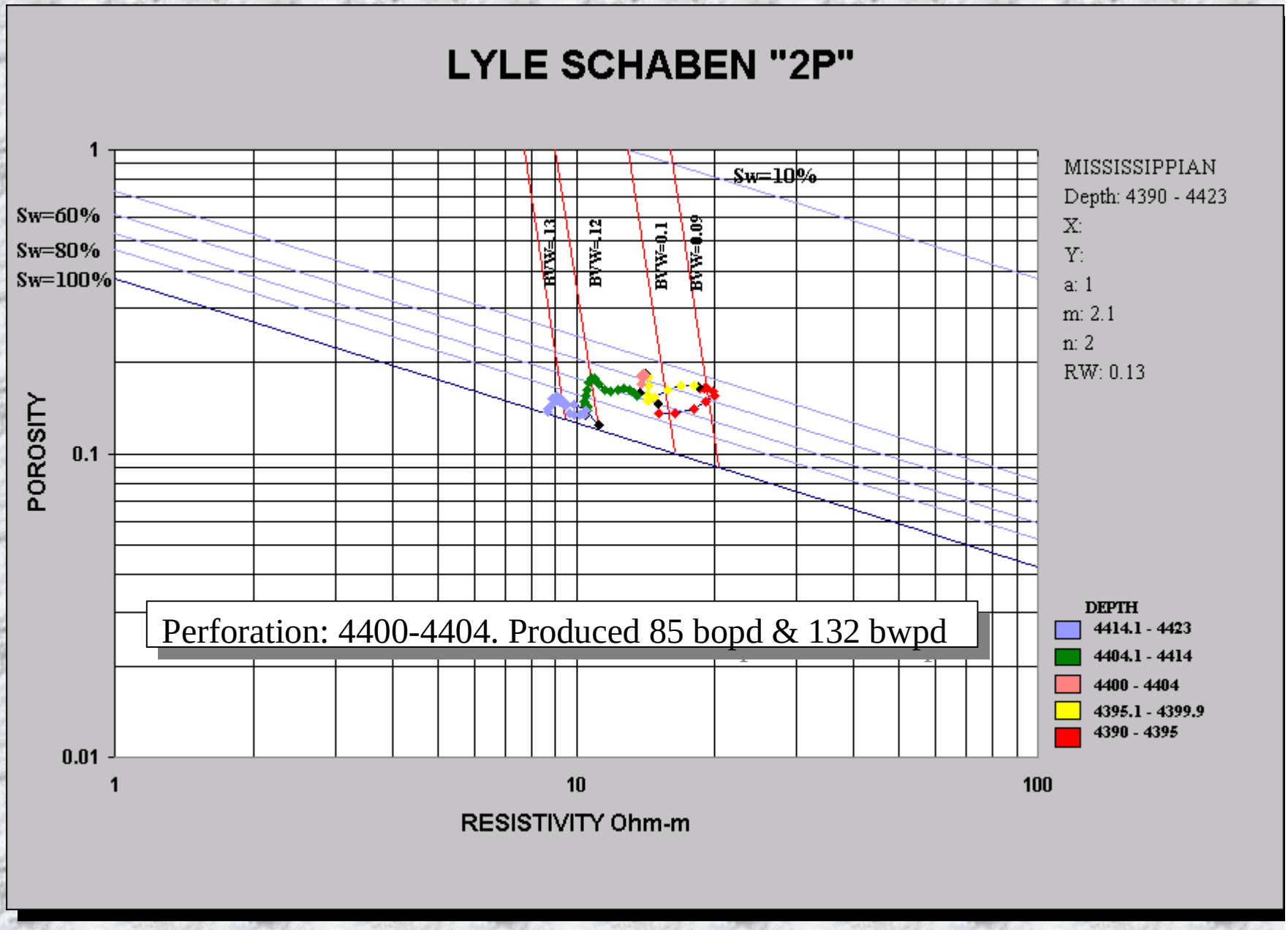


PfEFFER VERSION 2.0/PRO

REAL–TIME INTERACTIVE LOG ANALYSIS.

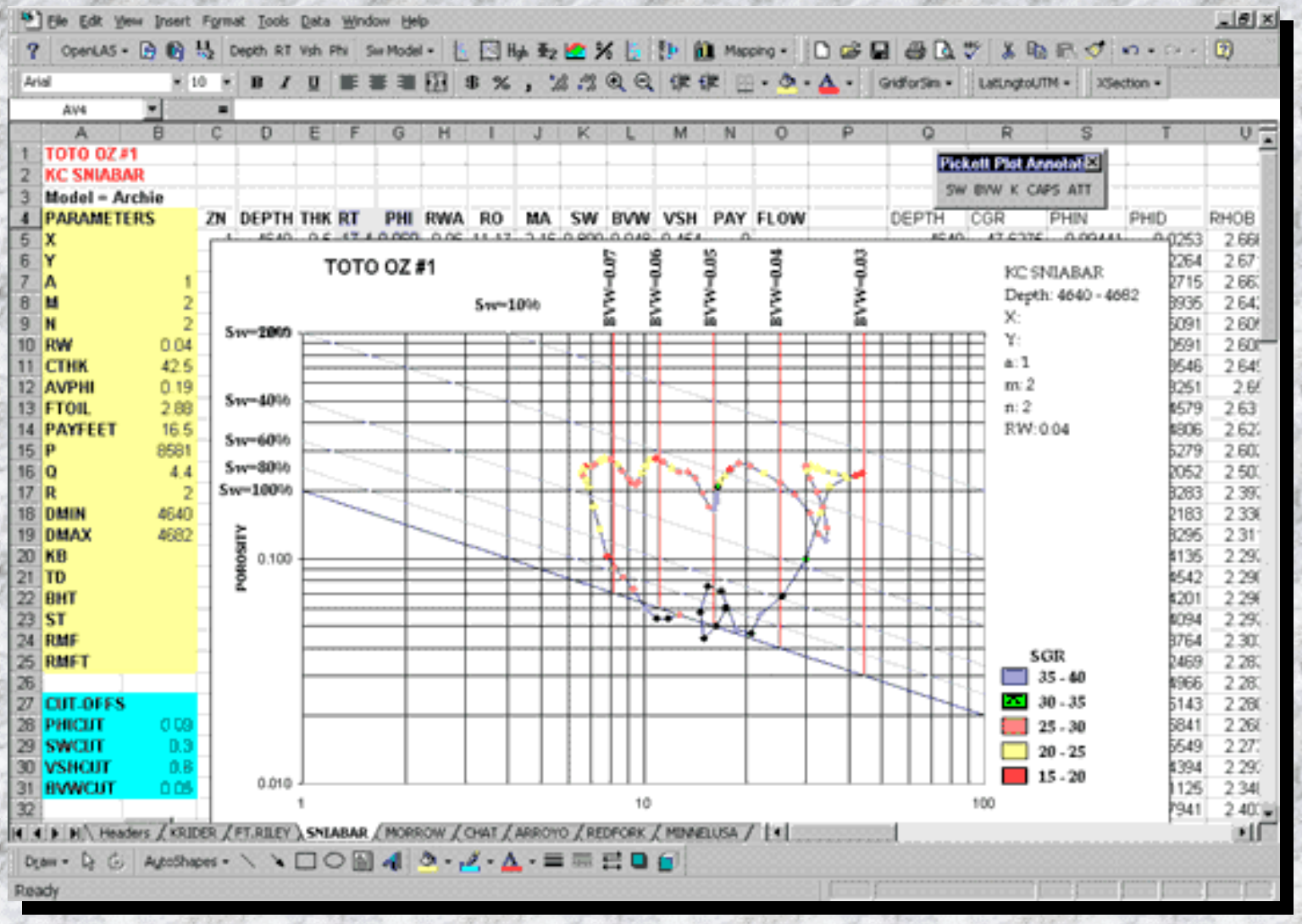
- Petrofacies Evaluation of Formations For Engineering Reservoirs
- PfEFFER Ver. 2.0 -- February 1998
- Spreadsheet Based
- Digital Logs or Manual Entry
- Interactive
- Modules (8,000 lines of Visual Basic)

PfEFFER VERSION 2.0/PRO
REAL-TIME INTERACTIVE LOG ANALYSIS.



PfEFFER VERSION 2.0/PRO

REAL–TIME INTERACTIVE LOG ANALYSIS.



PfEFFER VERSION 2.0/PRO

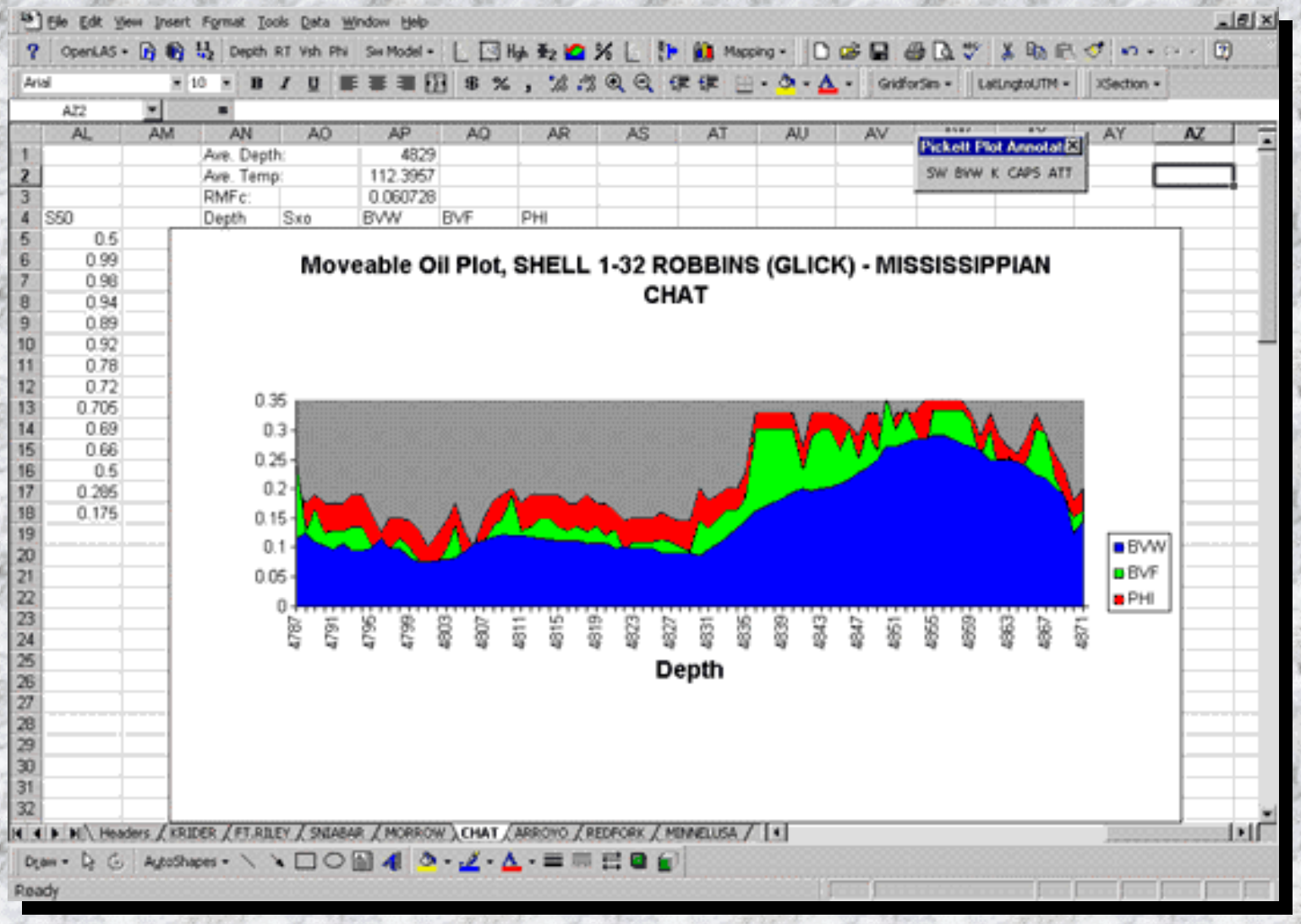
REAL–TIME INTERACTIVE LOG ANALYSIS.

New Features

- Vshale
- Improved Porosity Calculations
- Shaly Sand Models
- Hough Transforms
- Moveable Hydrocarbons
- Lithological Analysis
- Improved 2D and 3D Mapping
- Generate Input Tables for Reservoir Simulation

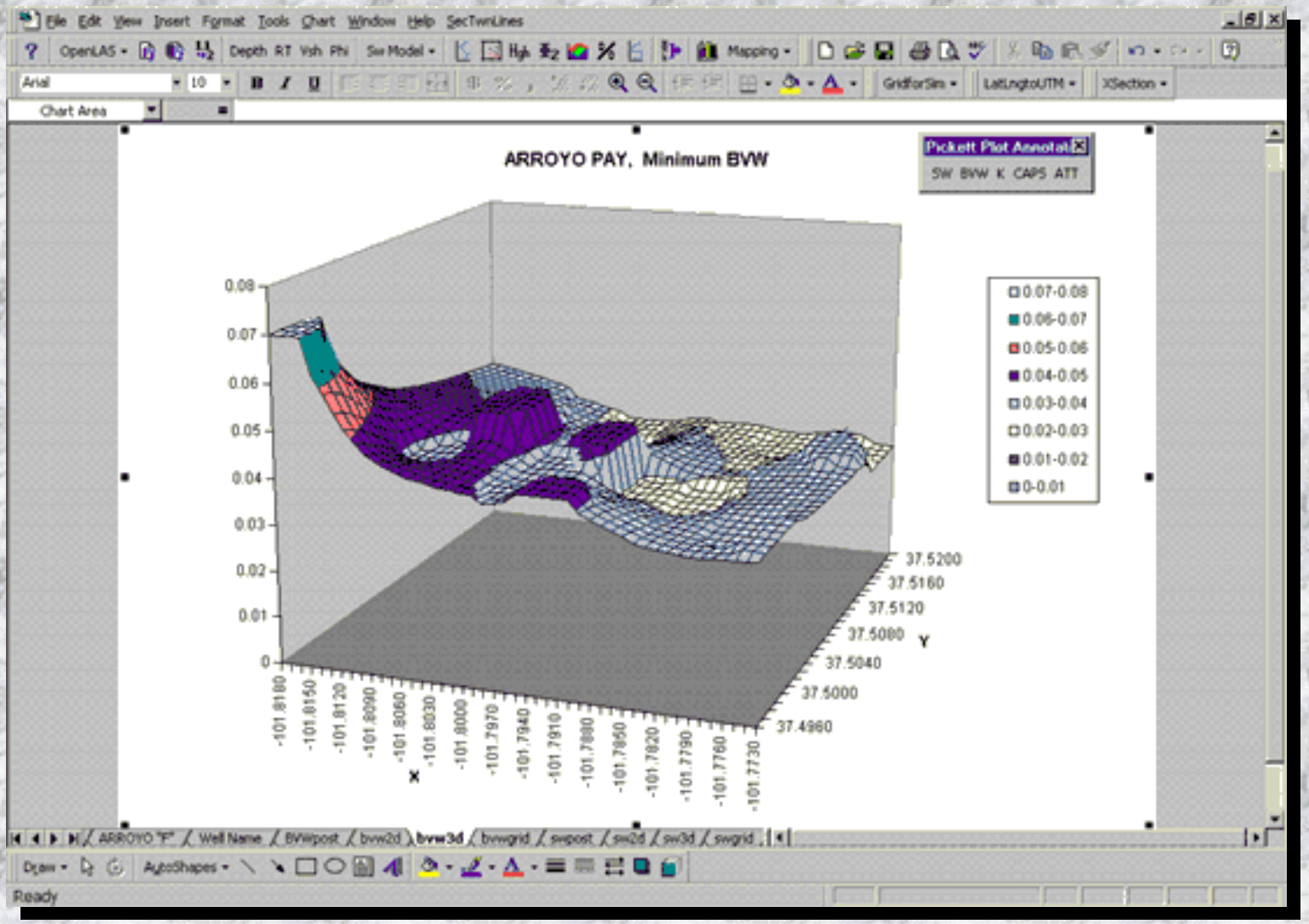
PfEFFER VERSION 2.0/PRO

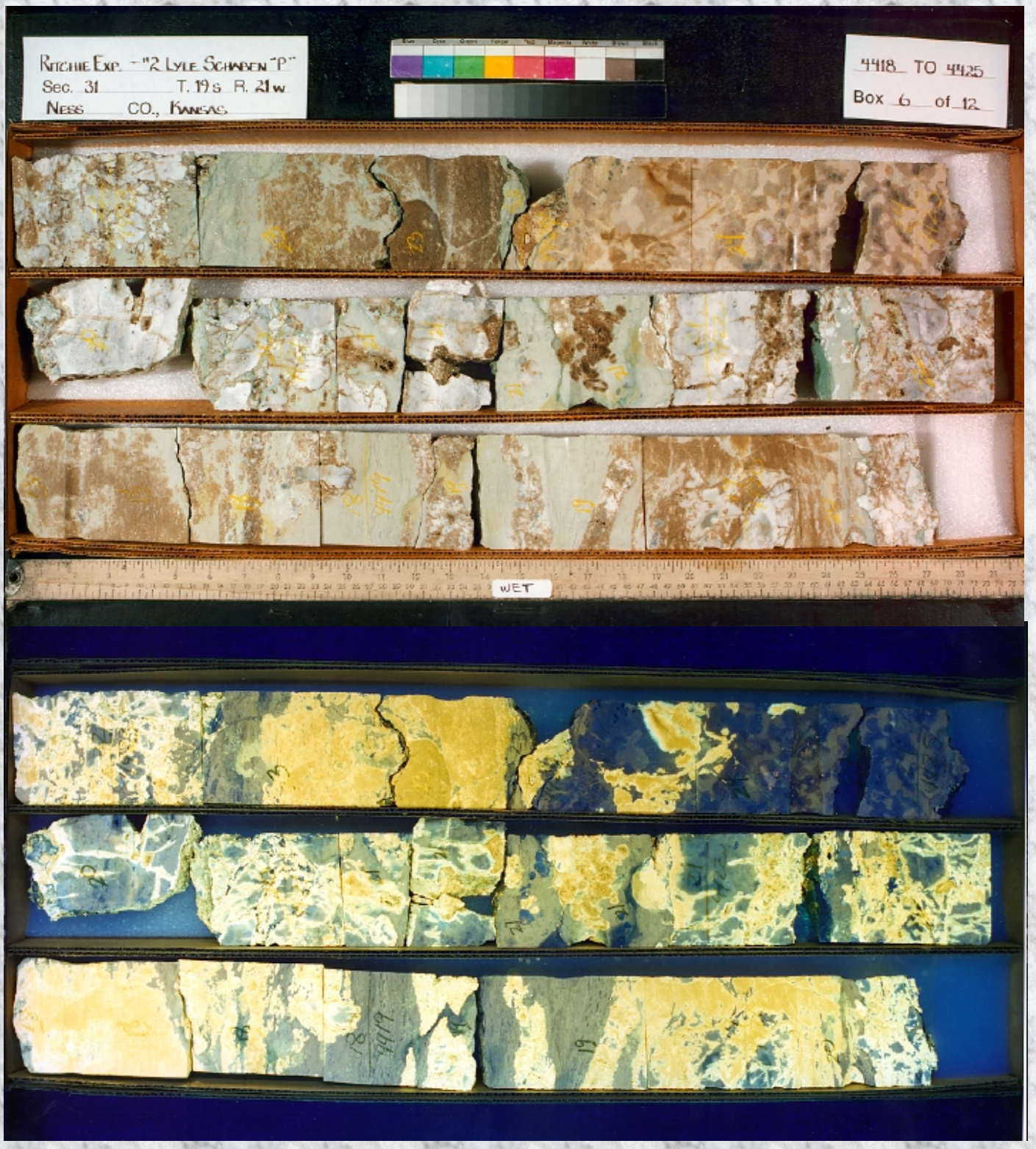
REAL–TIME INTERACTIVE LOG ANALYSIS.



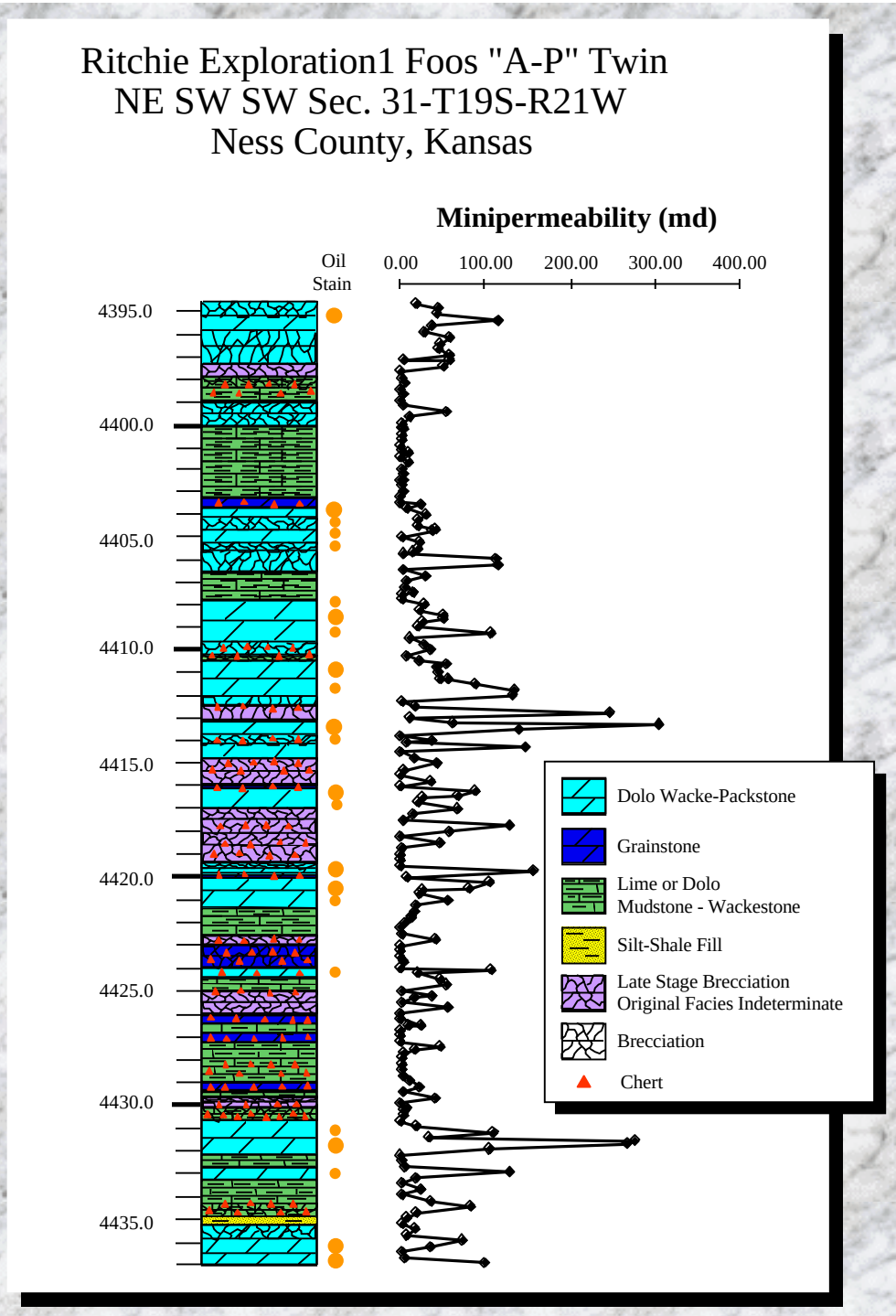
PfEFFER VERSION 2.0/PRO

REAL–TIME INTERACTIVE LOG ANALYSIS.

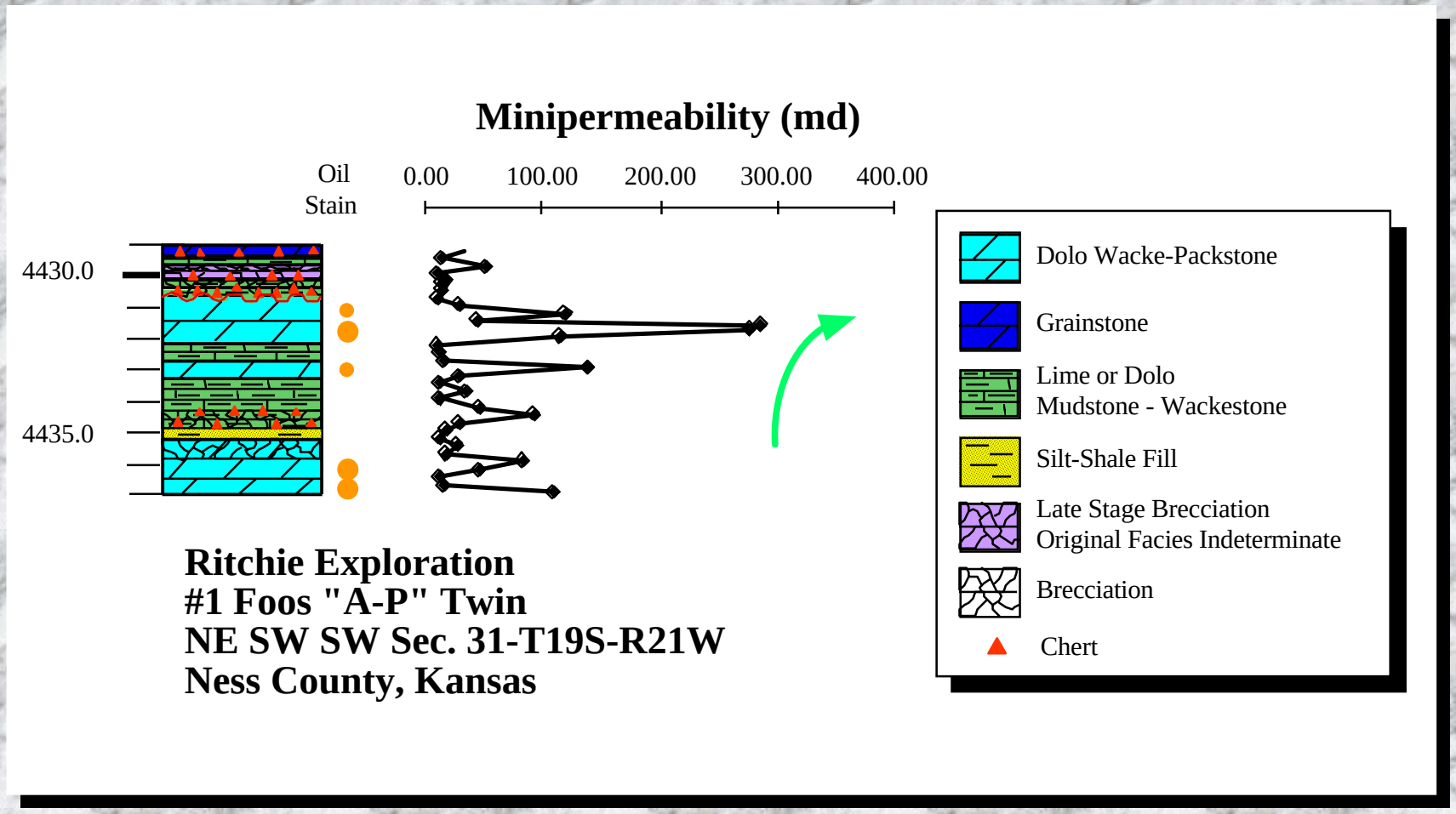



RITCHIE EXP. - "2 LYLE SCHABEN "P"
SEC. 31 T. 19 S. R. 21 W
NESS CO., KANSAS.
4418 TO 4425
BOX 6 OF 12
WET

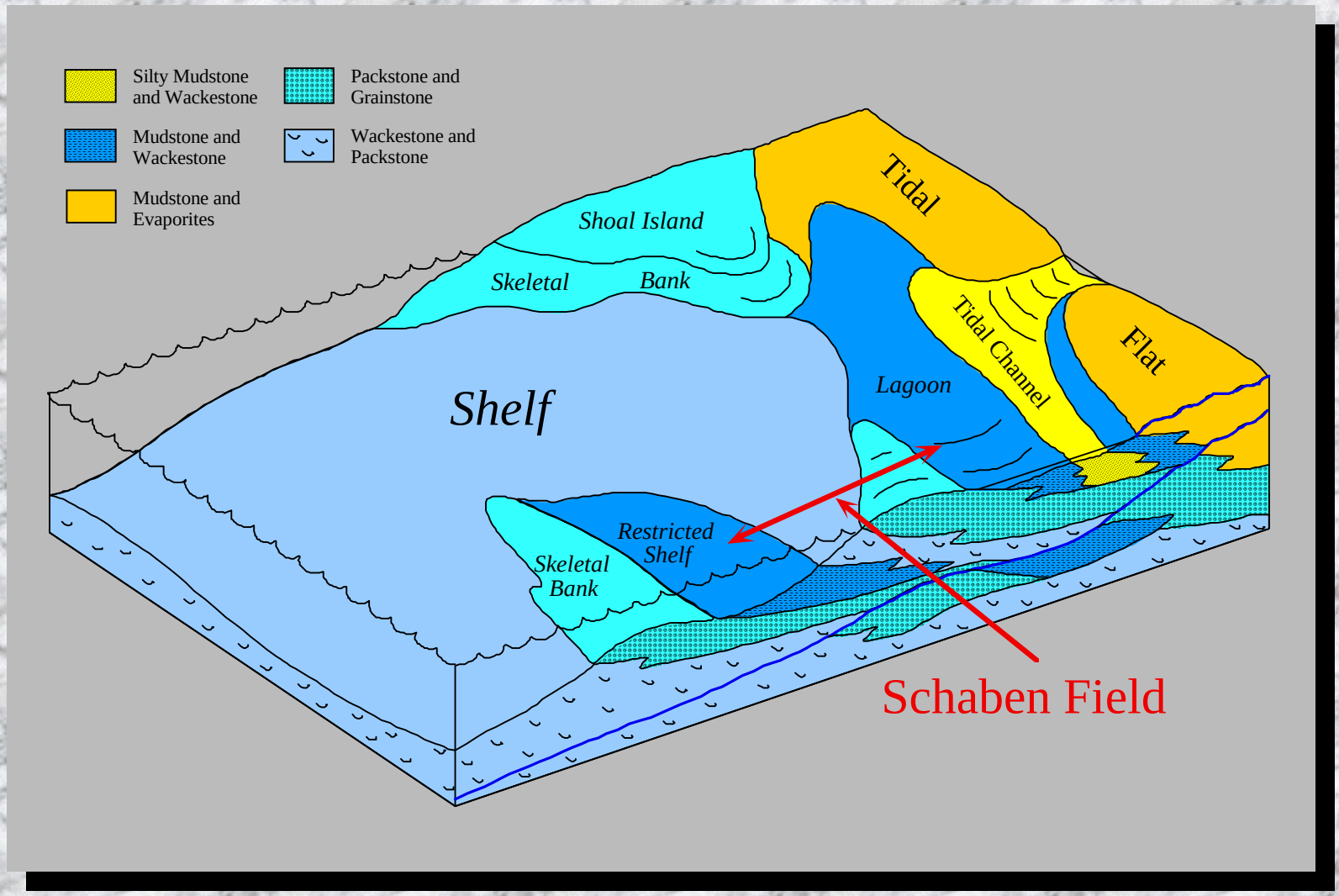
Geologic Reservoir Description



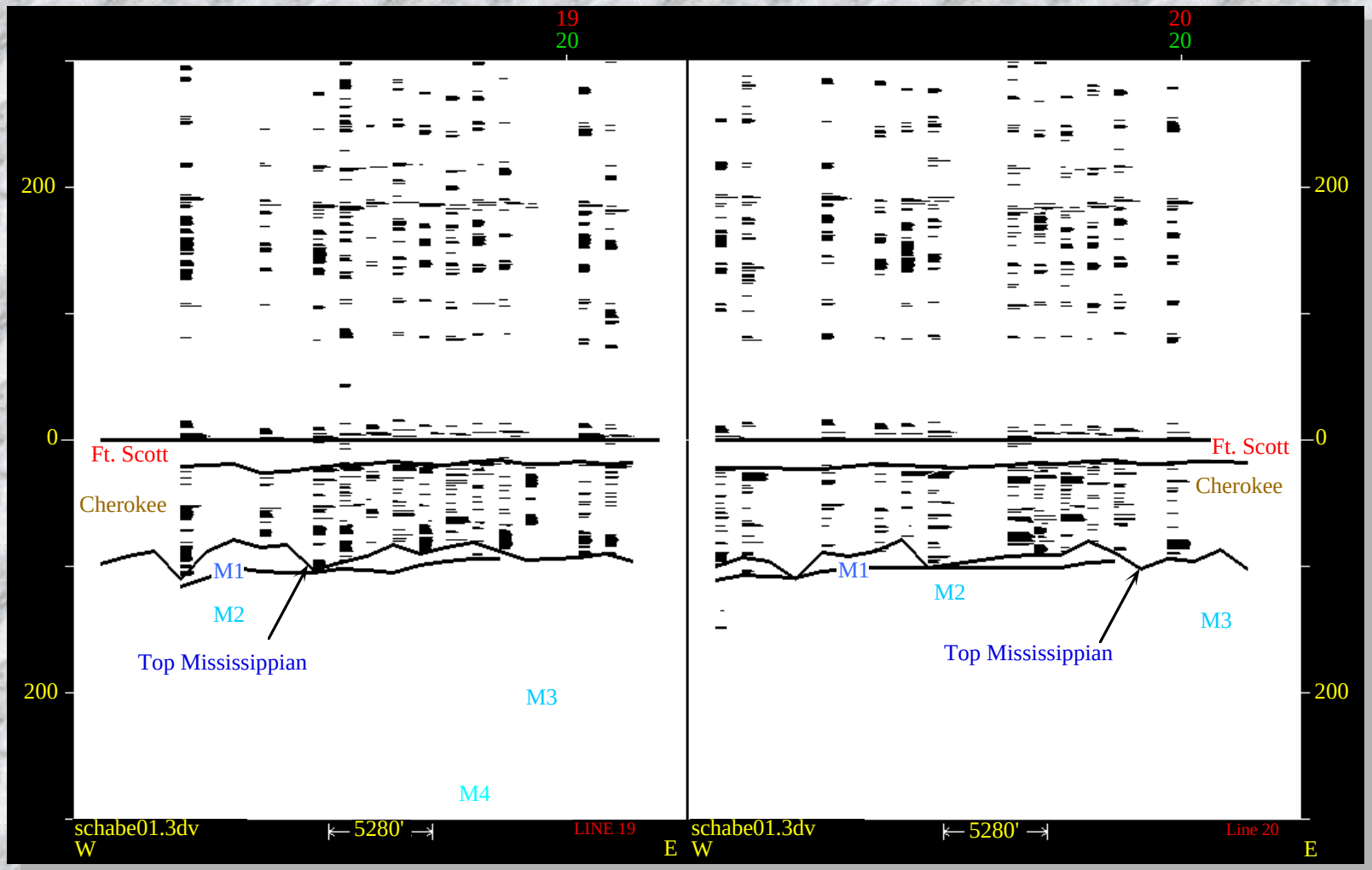
Geologic Reservoir Description



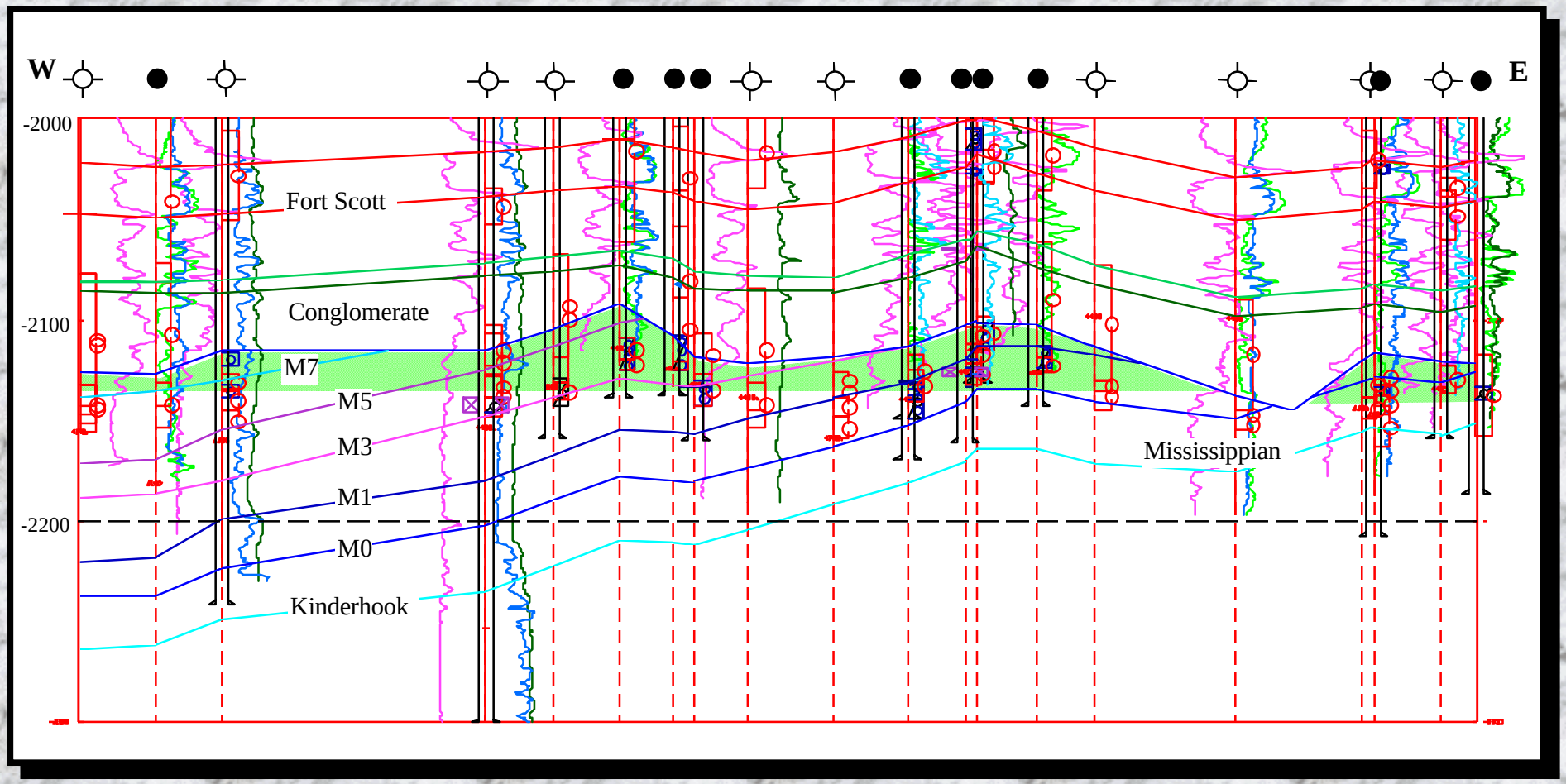
Depositional Model



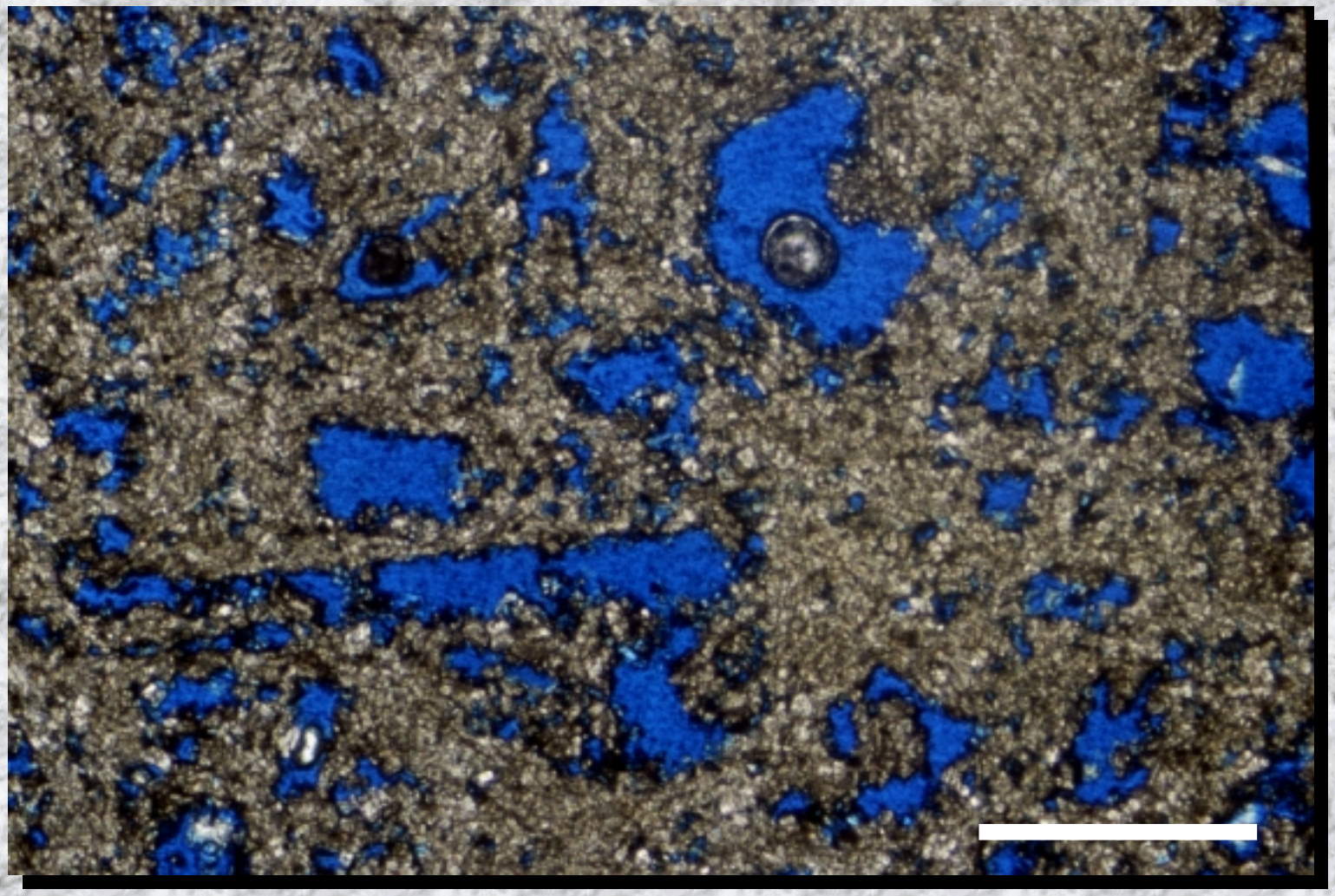
Schaben Field: Visualization Pseudoseismic



Schaben Field
Structure Cross-Section

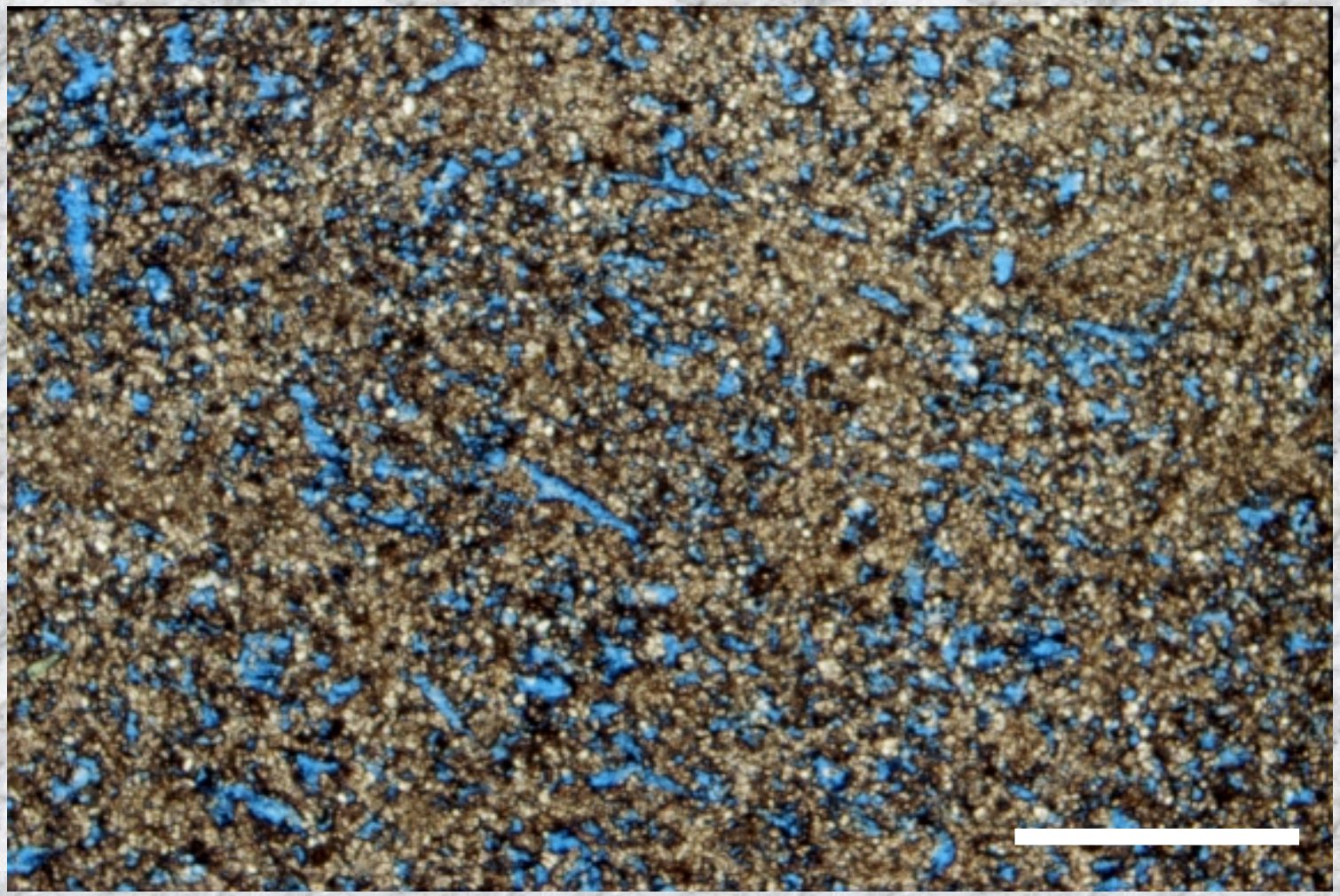


Reservoir Facies
Skeletal Wackestone - Packstone



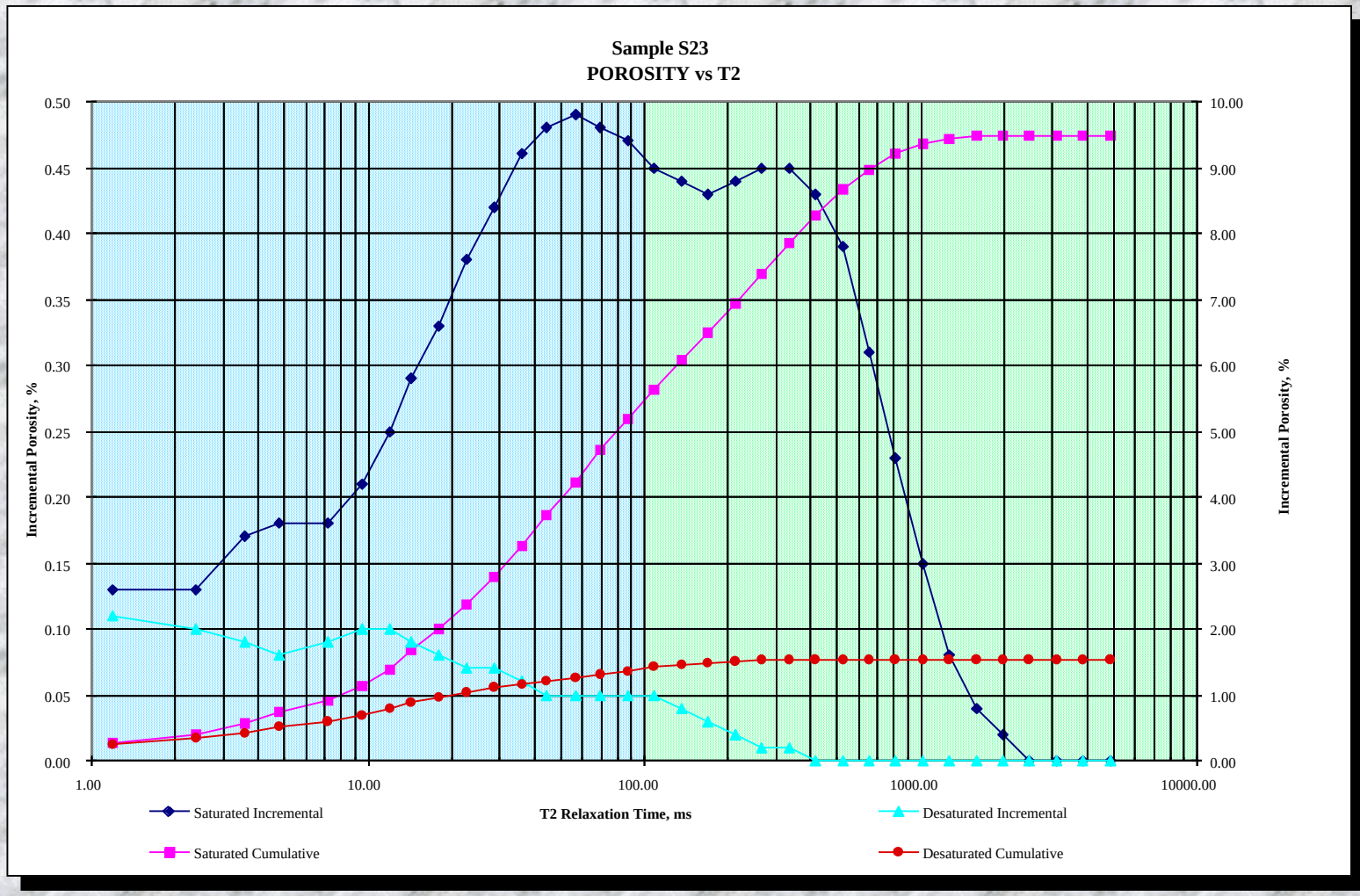
Ritchie 2 Schaben P

Spicule-Rich Mudstone -Wackestone Facies

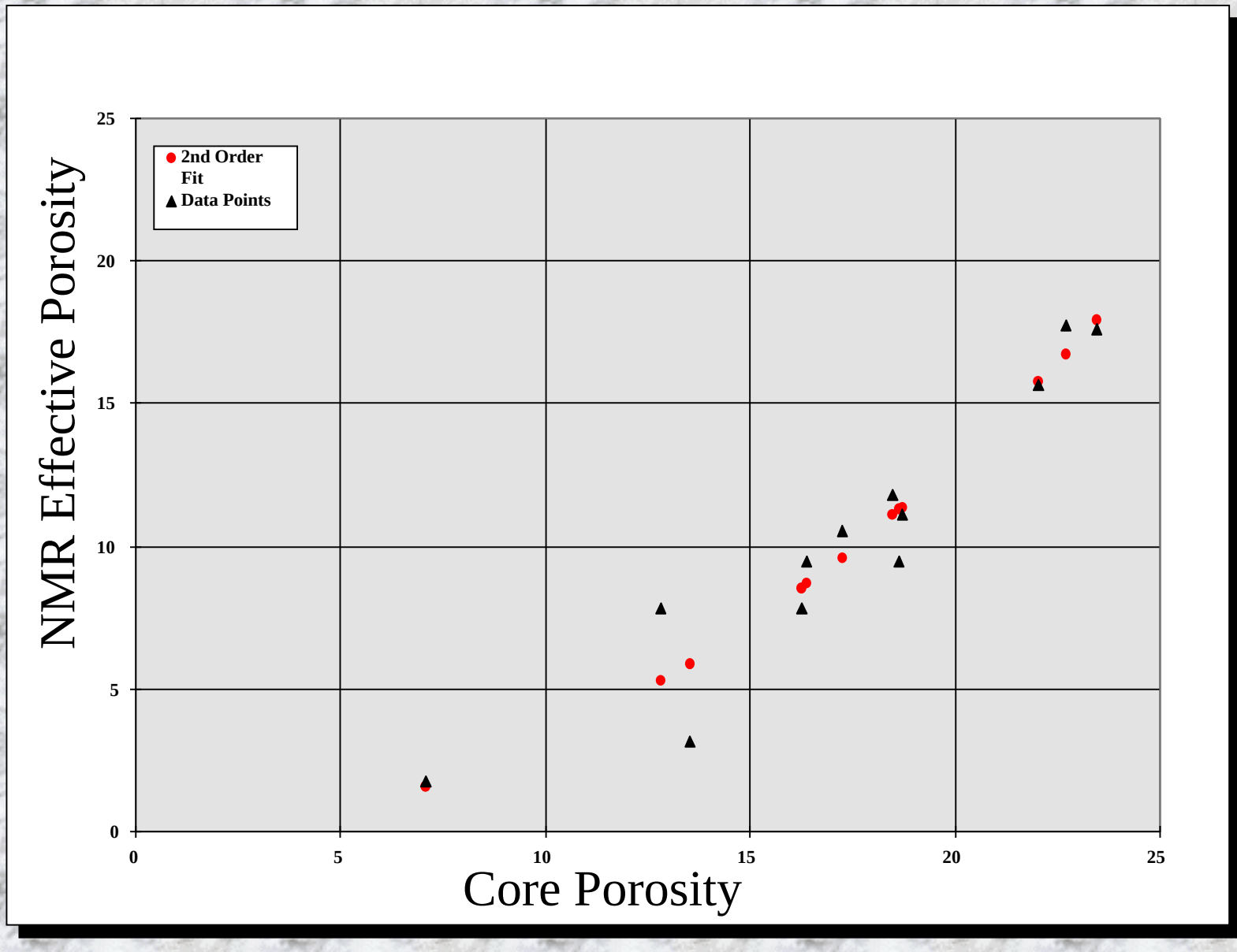


Ritchie 1 Moore B

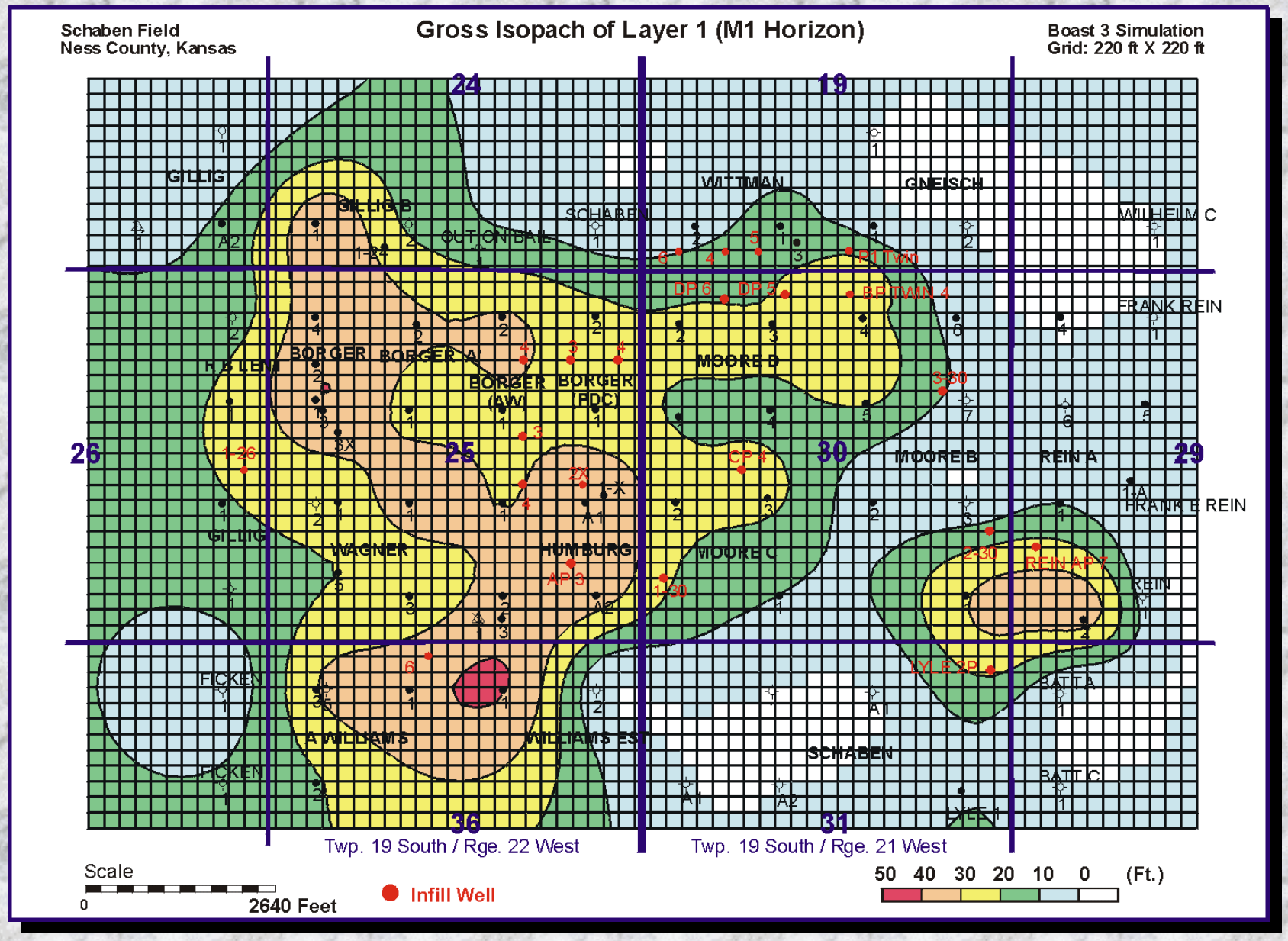
NMR Analysis of Core Plugs



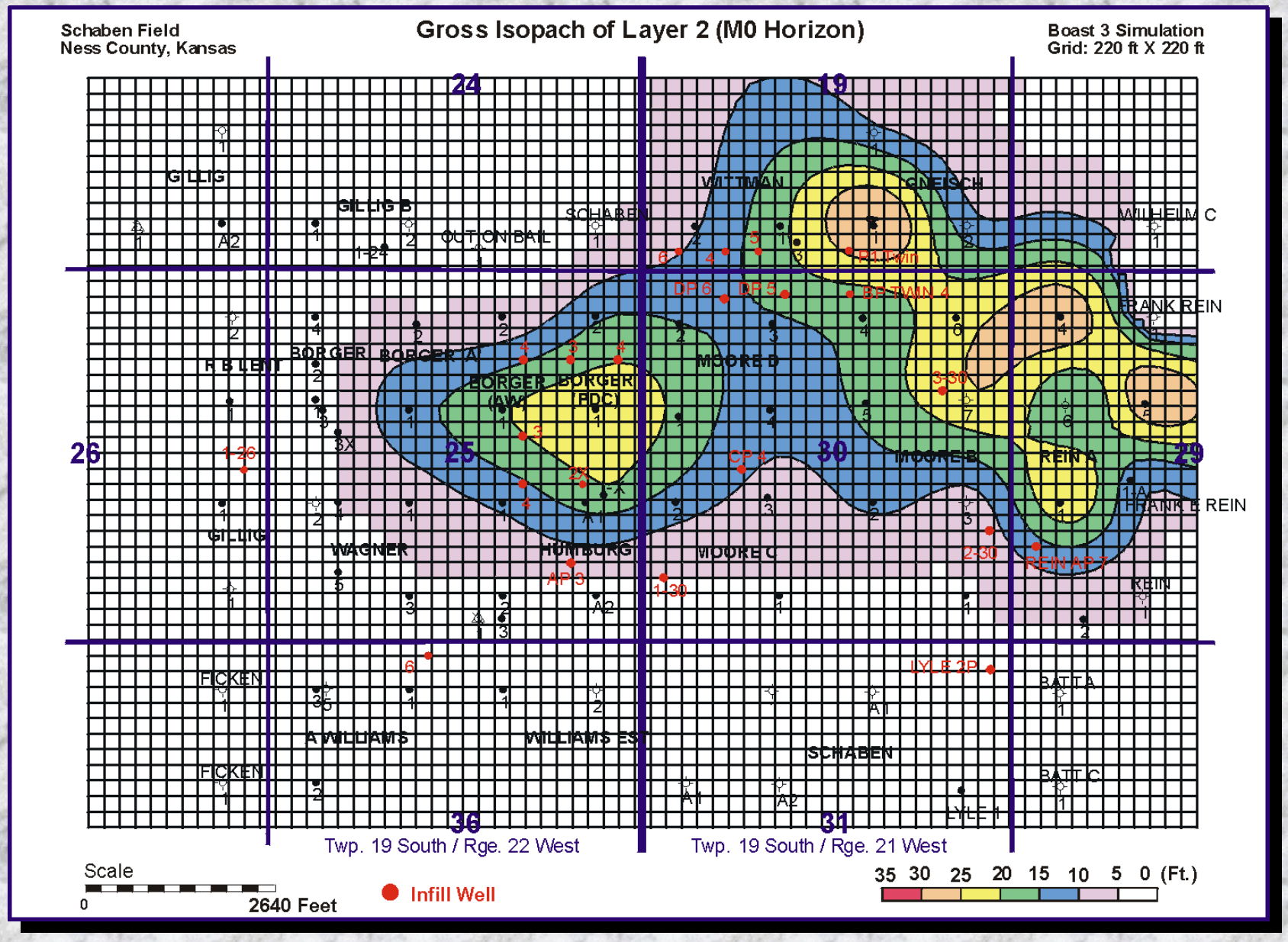
Schaben Field -- Effective Porosity



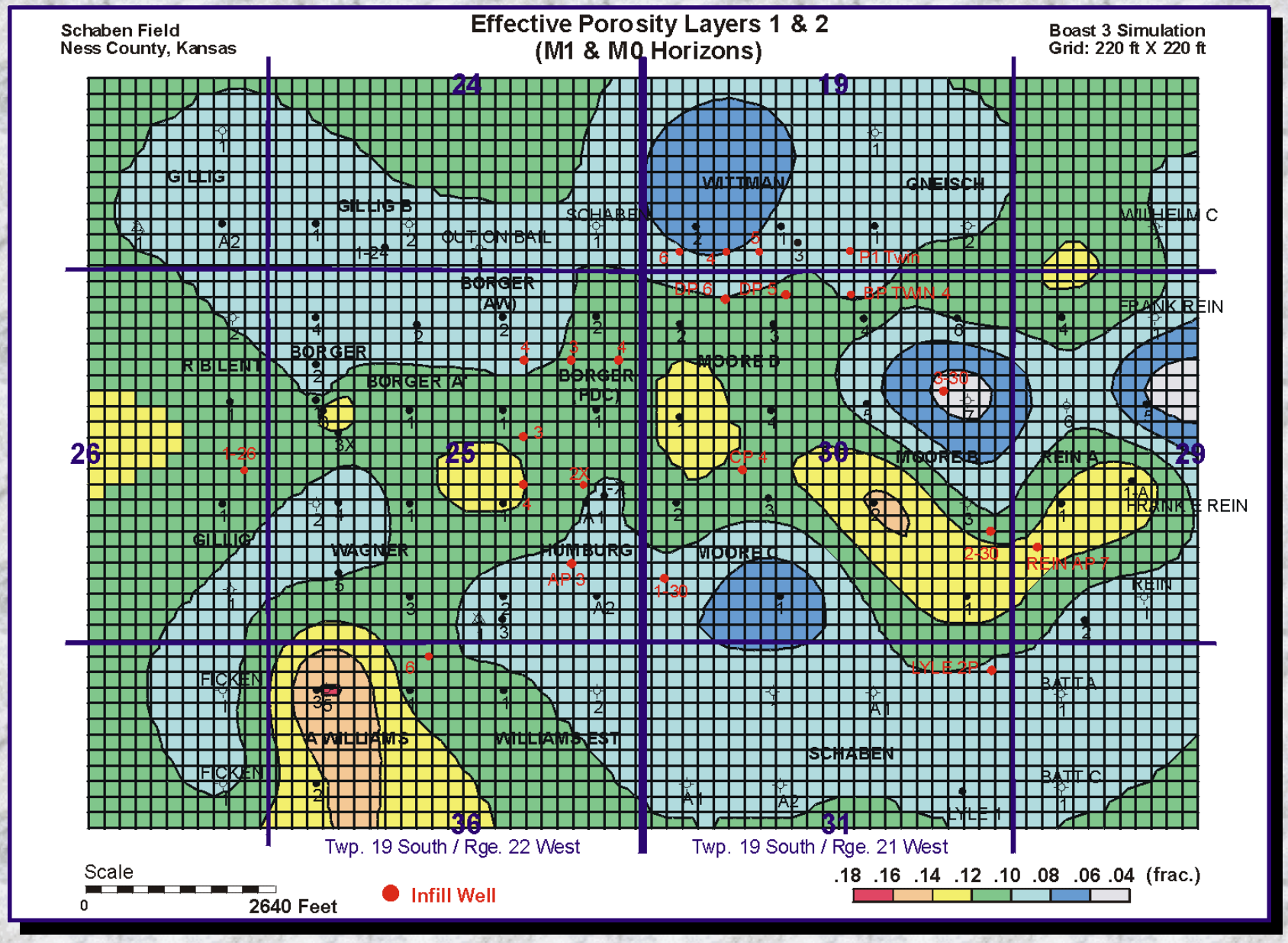
chaben Field -- Reservoir Characterization



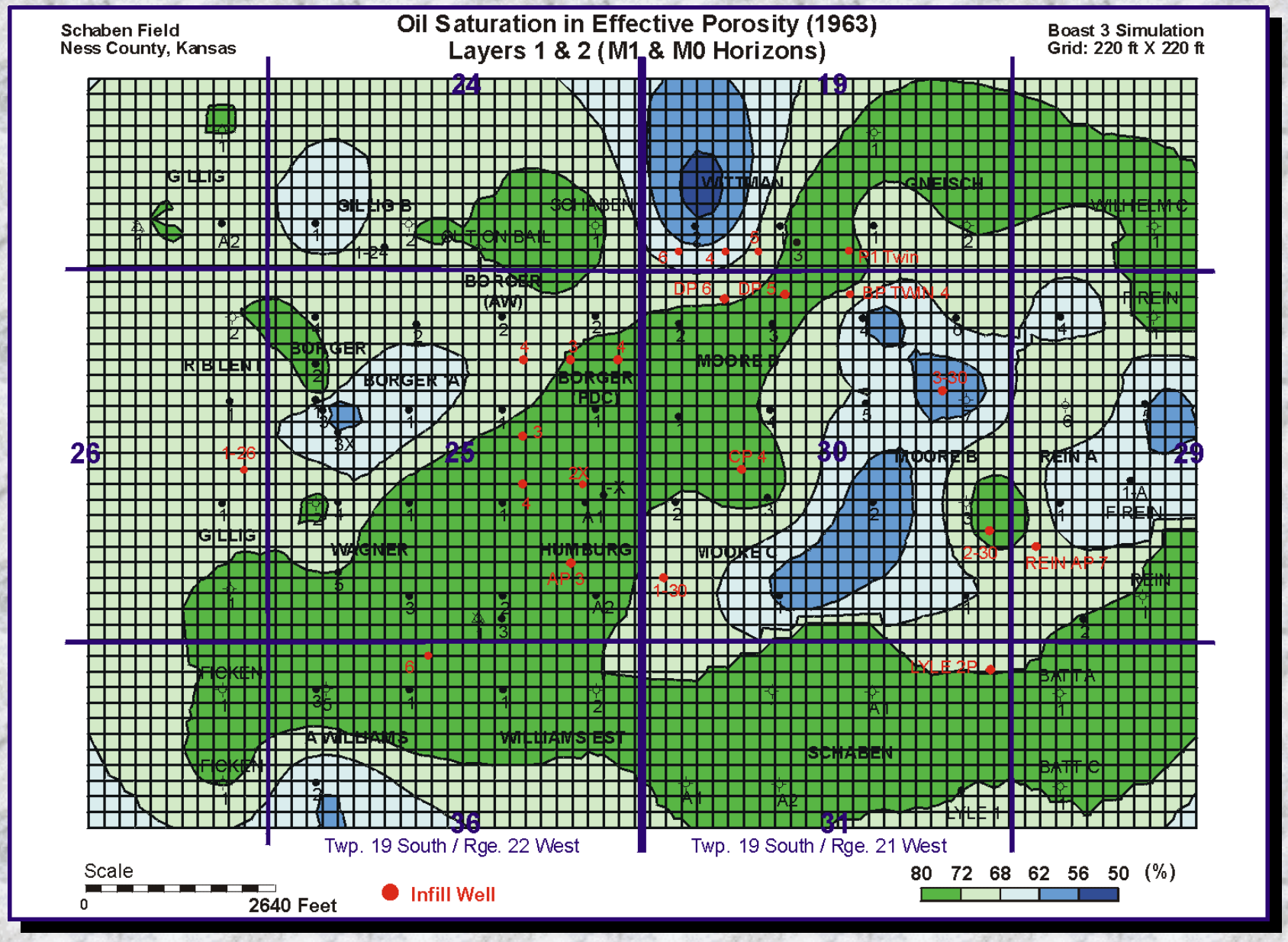
chaben Field -- Reservoir Characterization



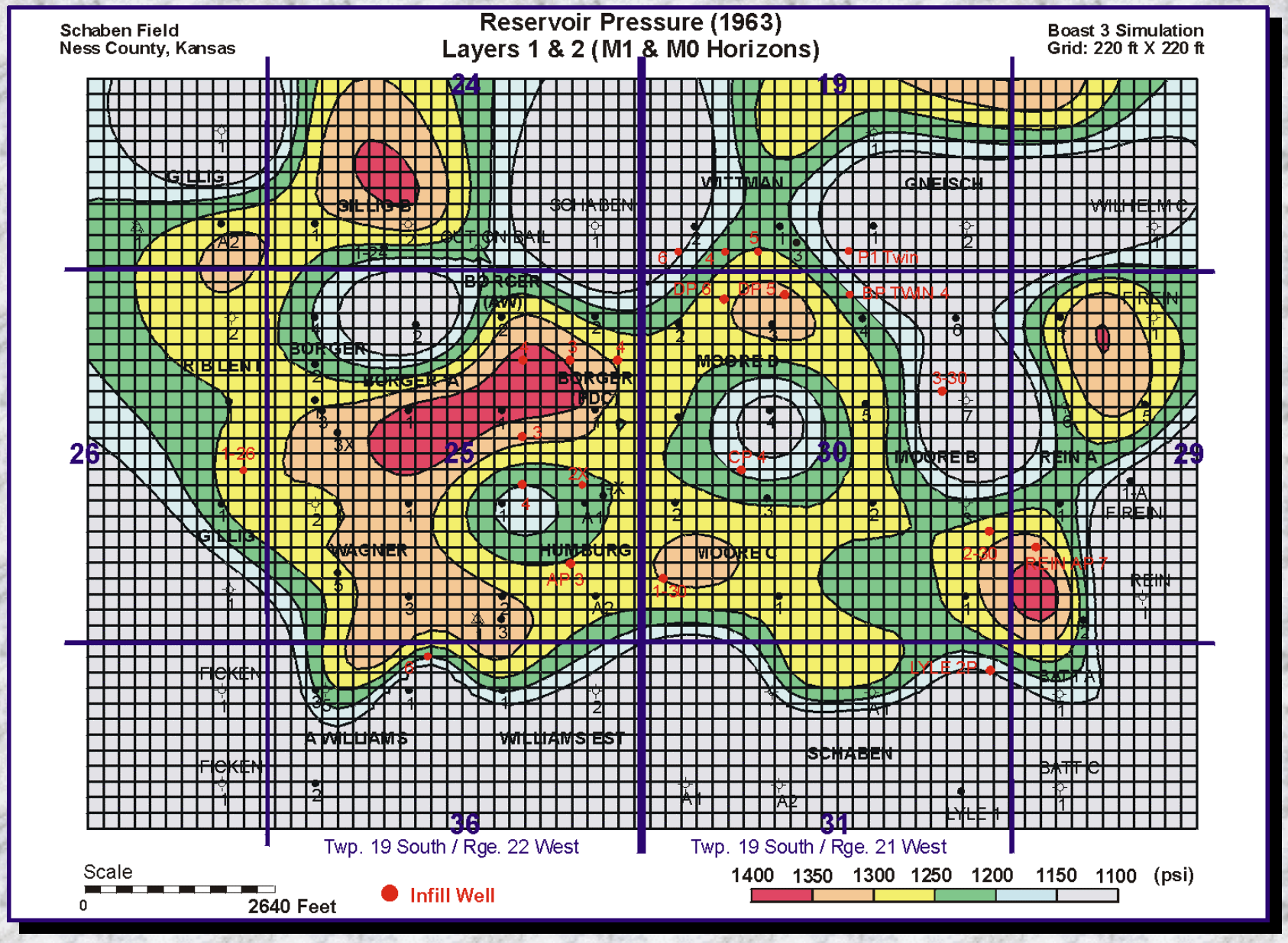
chaben Field -- Reservoir Characterization



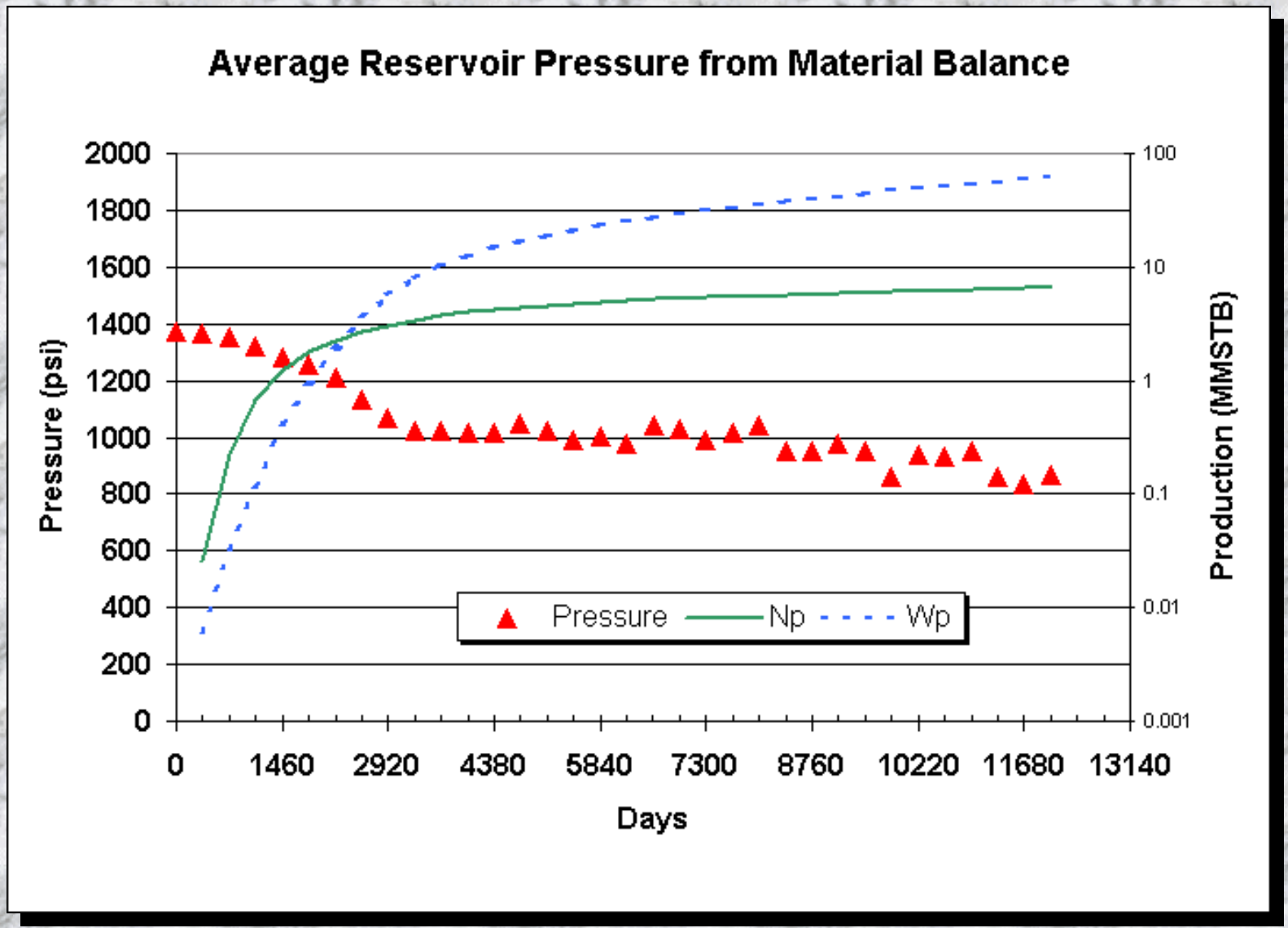
chaben Field -- Reservoir Characterization



chaben Field -- Reservoir Characterization

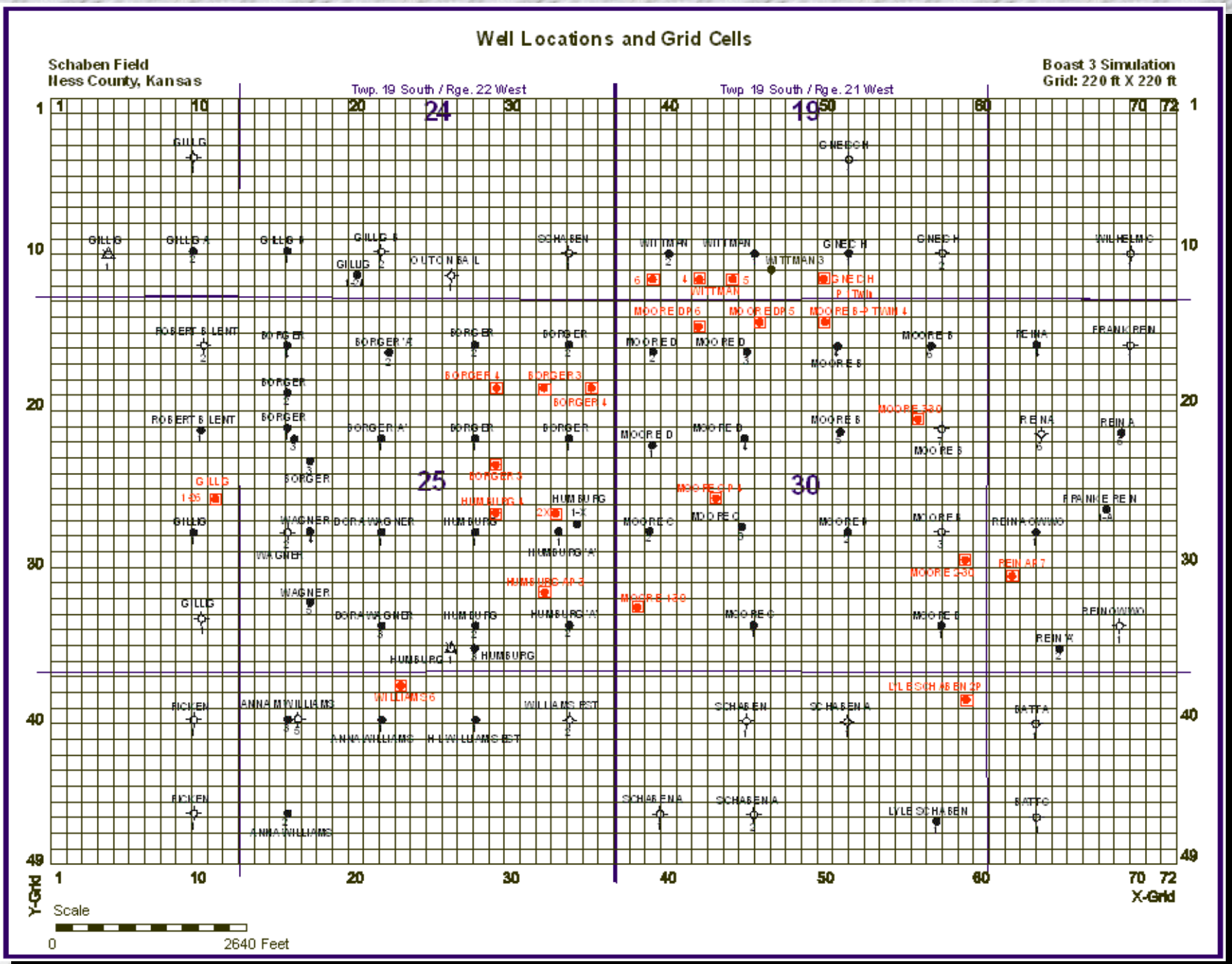


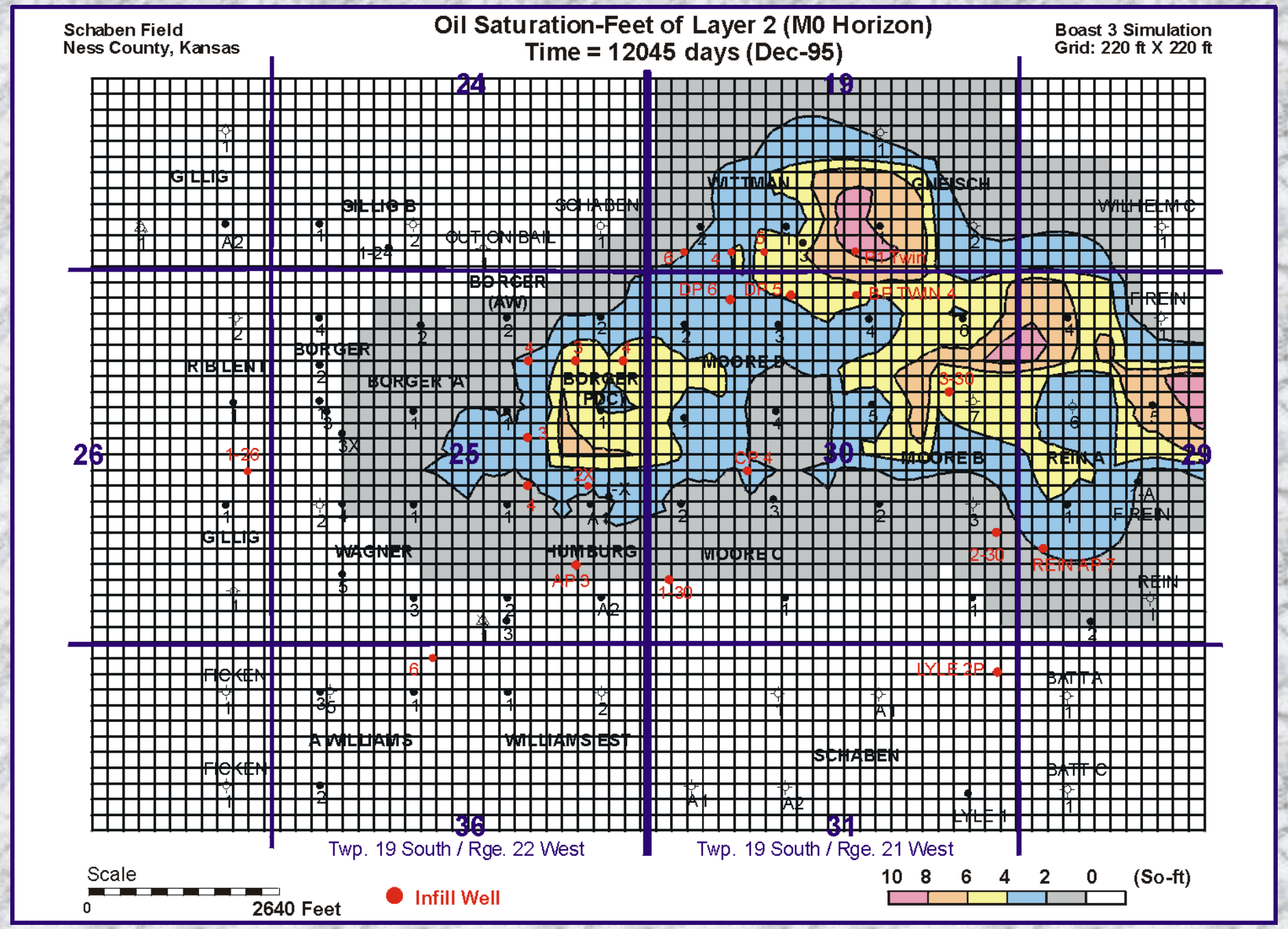
Average Reservoir Pressure

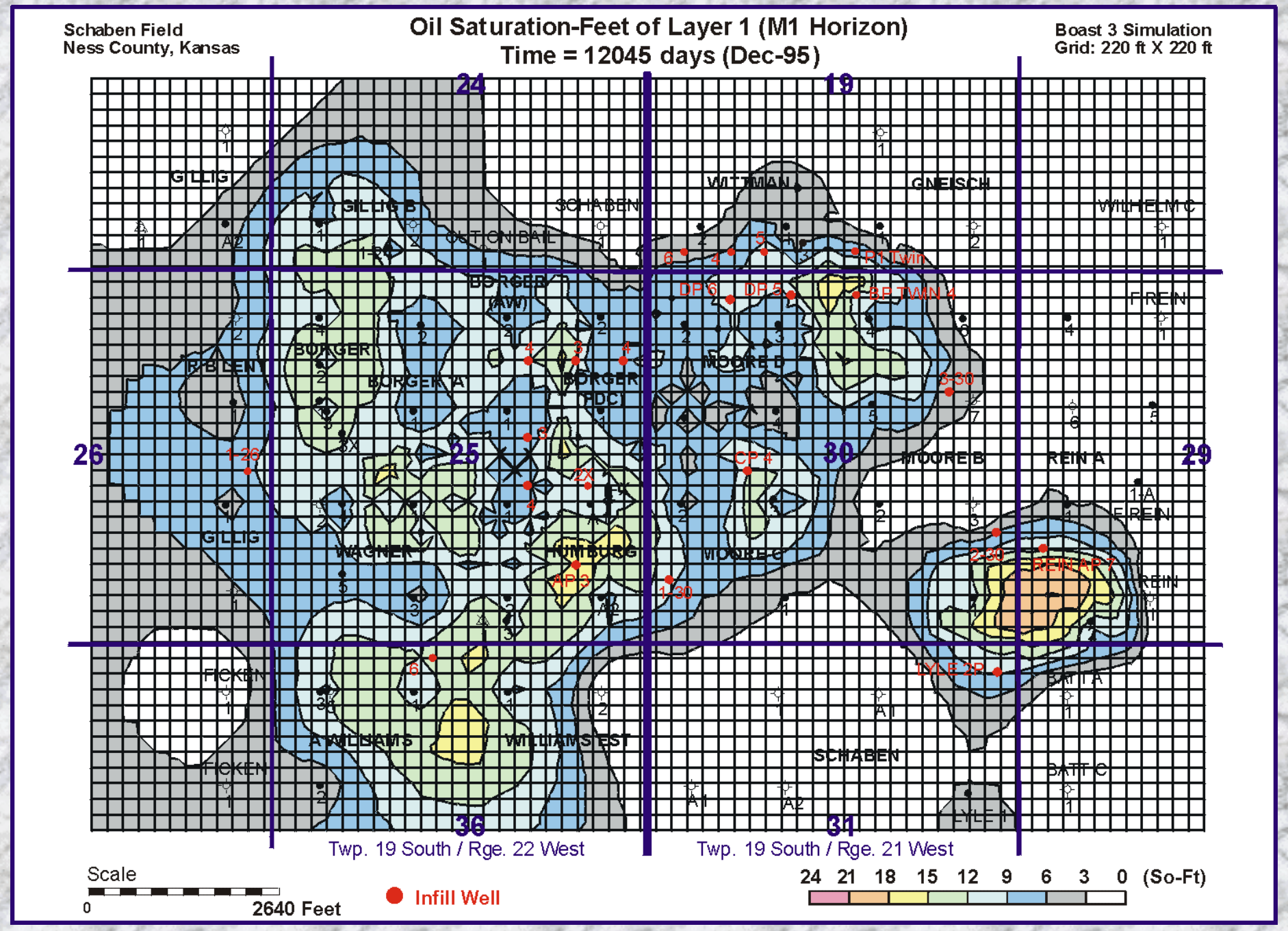


Schaben Field -- Reservoir Simulation

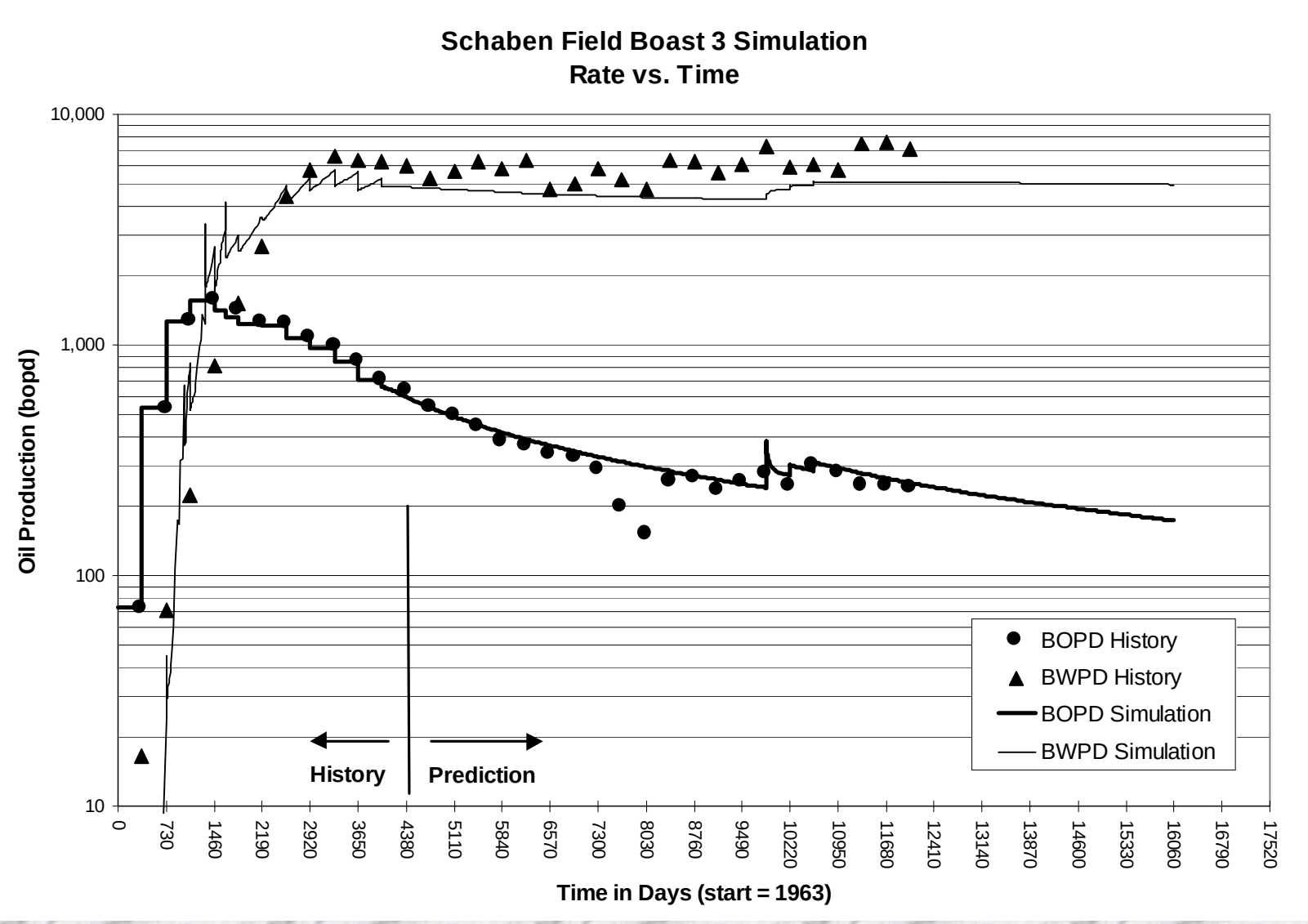
- PC-Based
- Freeware BOAST 3
  - Full Field Simulation
  - Revised to Two Layer Reservoir
- PfEFFER
  - Pre-Processor
  - Post-Processor
- Good Match
  - Oil and Water Rates
  - 34 years of history
- Results
  - Located 22 Infill Wells to Decrease Spacing
  - Good Match to Performance Prediction


Well Locations and Grid Cells
Schaben Field
Ness County, Kansas
Boast 3 Simulation
Grid: 220 ft X 220 ft
Twp. 19 South / Rge. 22 West
Twp. 19 South / Rge. 21 West
24
19
25
30
Y-Grid
X-Grid
Scale
0
2640 Feet

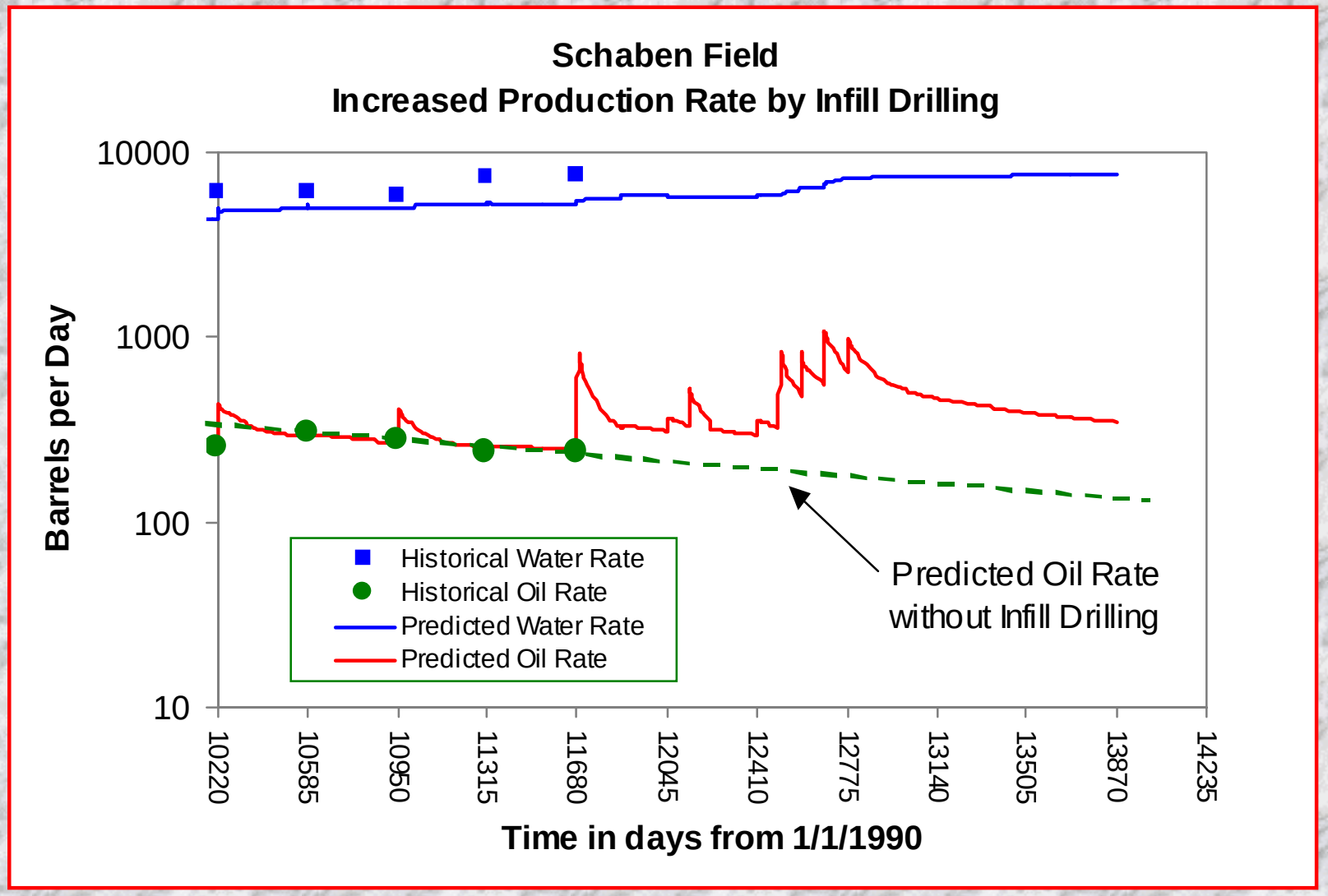

Schaben Field
Ness County, Kansas
Oil Saturation-Feet of Layer 2 (M0 Horizon)
Time = 12045 days (Dec-95)
Boast 3 Simulation
Grid: 220 ft X 220 ft
24
19
26
25
30
29
36
31
GILLIG
GILLIG B
SCHABEN
WITTMAN
GNEISCH
WILHELM C
OUTLON BAIL
BORGER (AW)
BORGER
BORGER A
BORGER PDC
MOORE D
MOORE B
MOORE C
REIN A
REIN
F REIN
1A F REIN
RIBLENT
WAGNER
HUMBURG
FICKEN
WILLIAMS
WILLIAMS EST
SCHABEN
BATT A
BATT C
1-24
1-26
1-30
2-30
3-30
AP 3
CP 4
DP 6
DP 5
B-P TWIN 4
P1 Twin
REIN AP 7
LYLE 2P
LYLE 1
Twp. 19 South / Rge. 22 West
Twp. 19 South / Rge. 21 West
Scale
0
2640 Feet
Infill Well
10 8 6 4 2 0 (So-ft)


Schaben Field
Ness County, Kansas
Oil Saturation-Feet of Layer 1 (M1 Horizon)
Time = 12045 days (Dec-95)
Boast 3 Simulation
Grid: 220 ft X 220 ft
24
19
26
25
30
29
36
31
GILLIG
GILLIG B
OSTERBAIL
SCHABEN
WITTMAN
GNEISCH
WILHELM C
BORGER (AW)
BORGER
BORGER A
BORGER FDC1
MOORE D
MOORE B
MOORE C
REIN A
REIN
WAGNER
HOMBURG
FICKEN
WILLIAMS
WILLIAMS EST
BATT A
BATT C
SCHABEN
DP 6
DP 5
B-P TWIN 4
PT Twin
CP 4
1-26
1-30
AP 3
2-30
REIN AP 7
LYLE 2P
Twp. 19 South / Rge. 22 West
Twp. 19 South / Rge. 21 West
Scale
0
2640 Feet
Infill Well
24 21 18 15 12 9 6 3 0 (So-Ft)

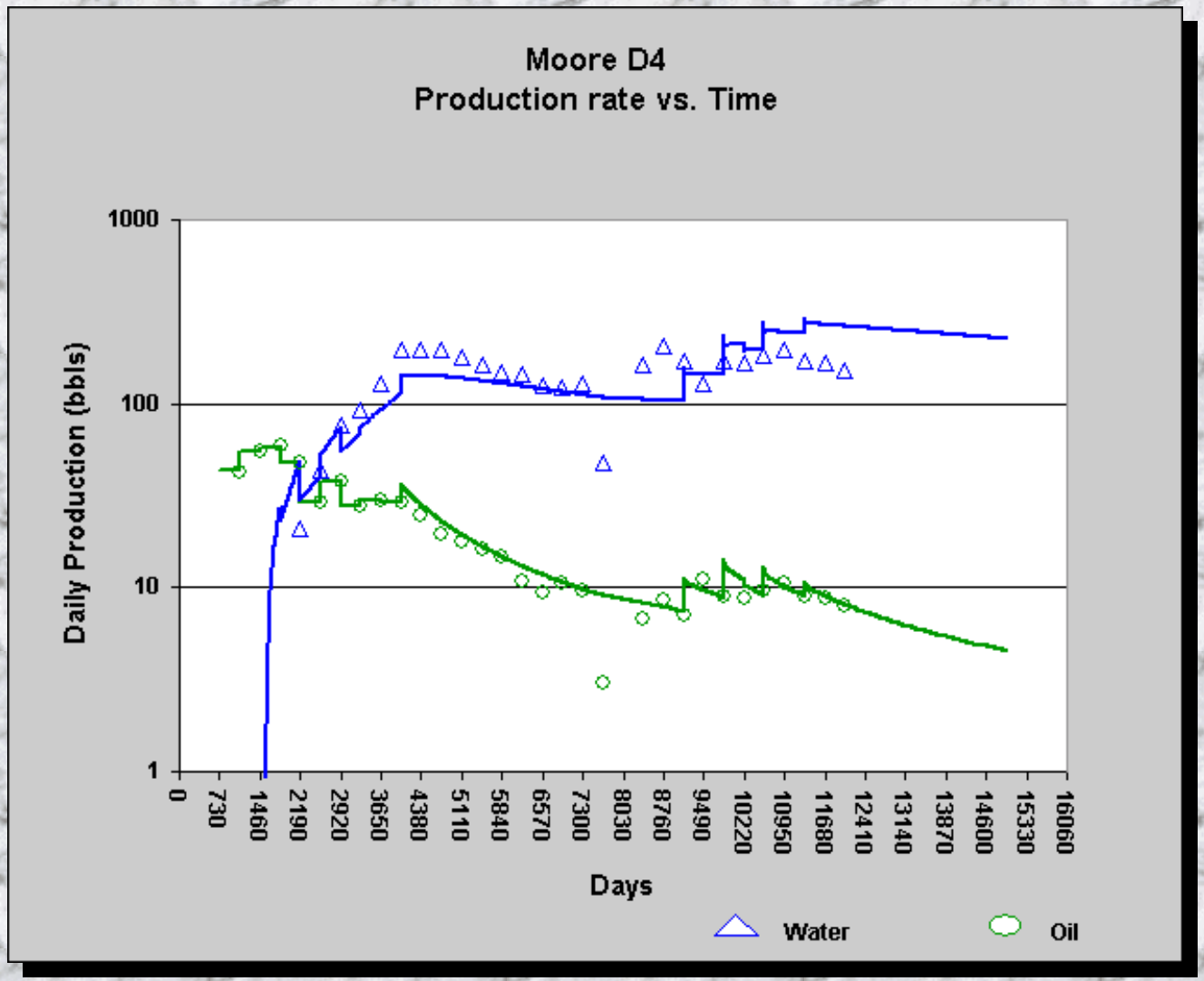
Schaben Field: History Match



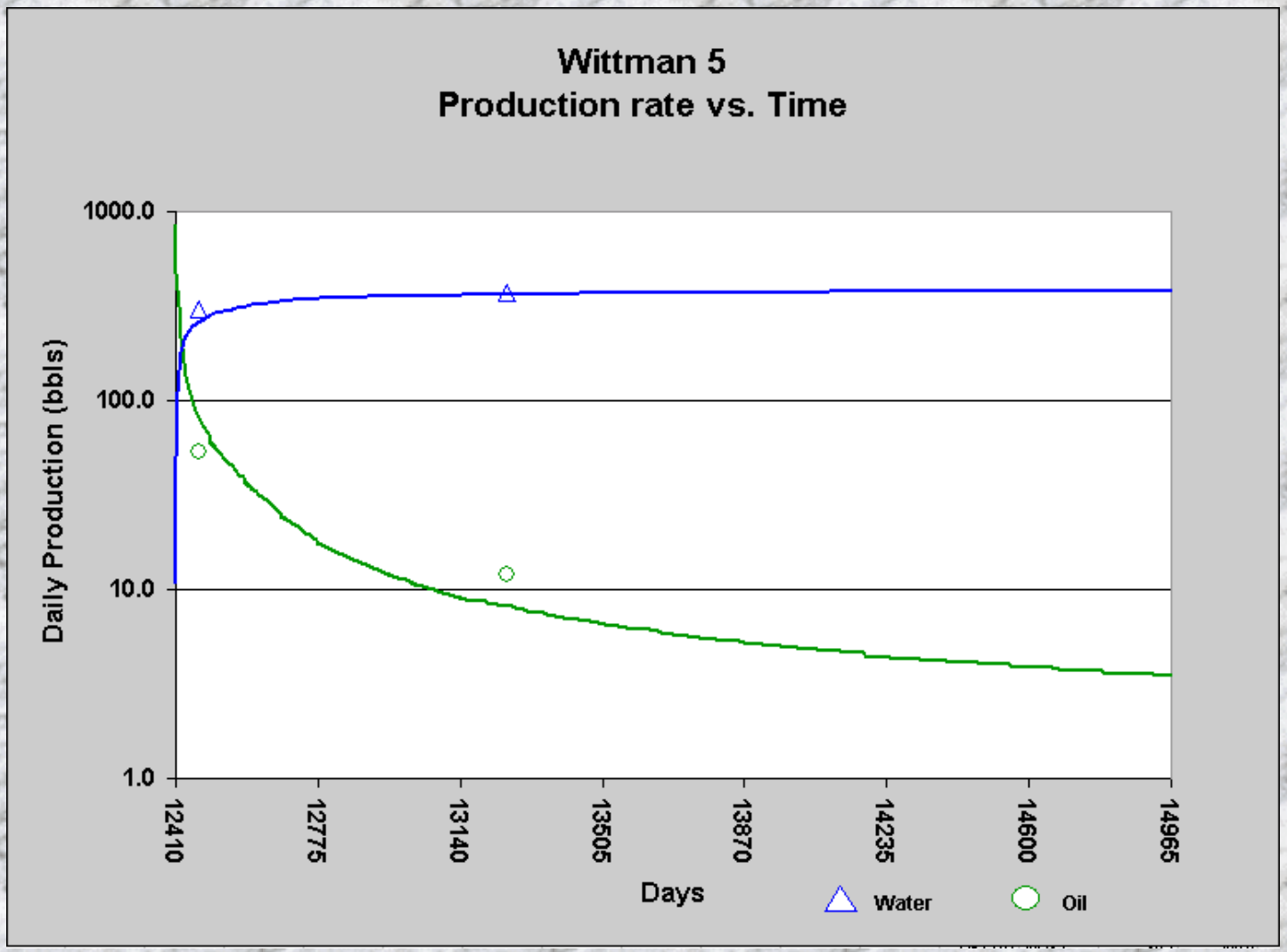
Schaben Field: Predicted Rates



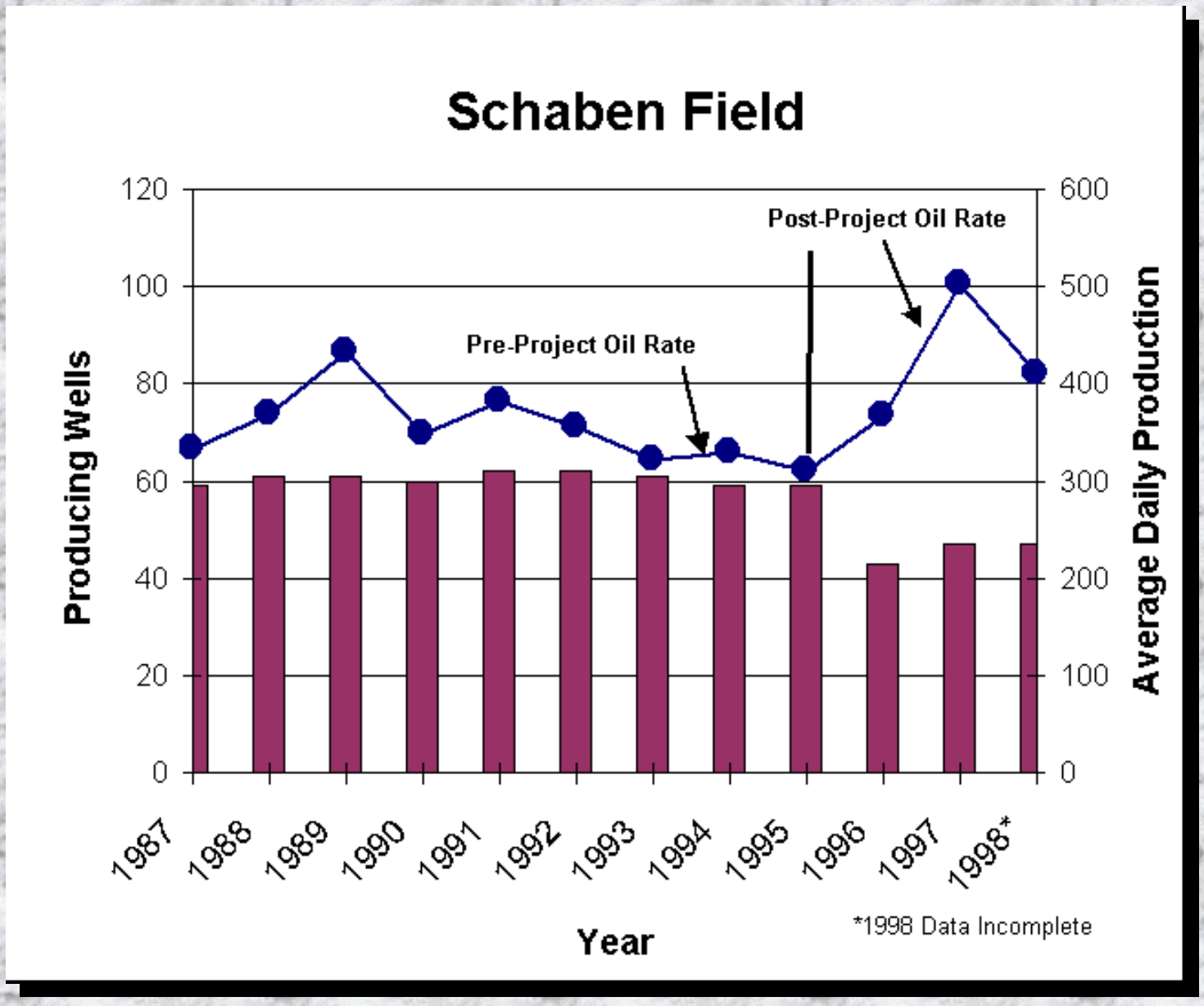
History Match: Existing Well



History Match: New Well



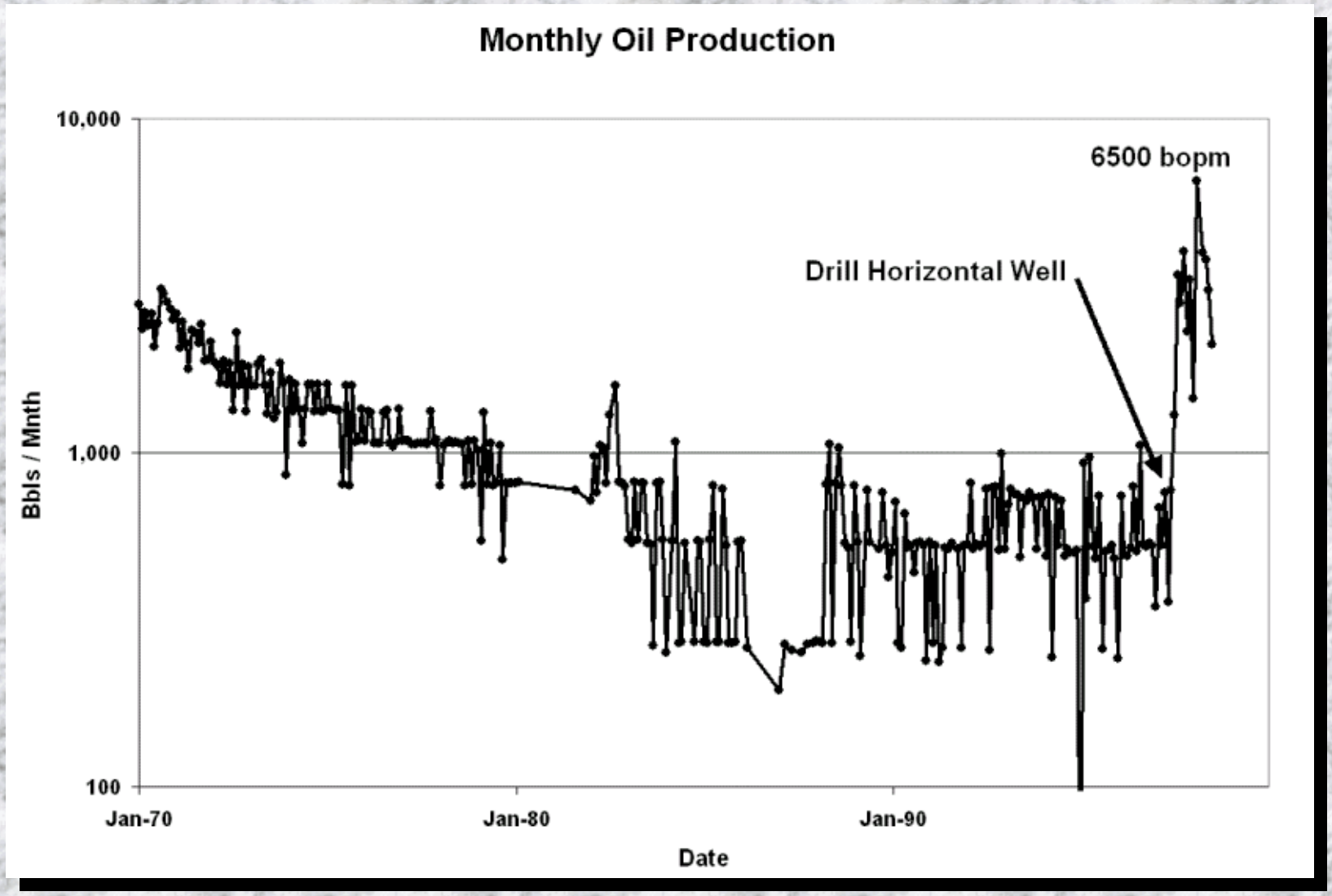
chaben Demonstration Site: Production



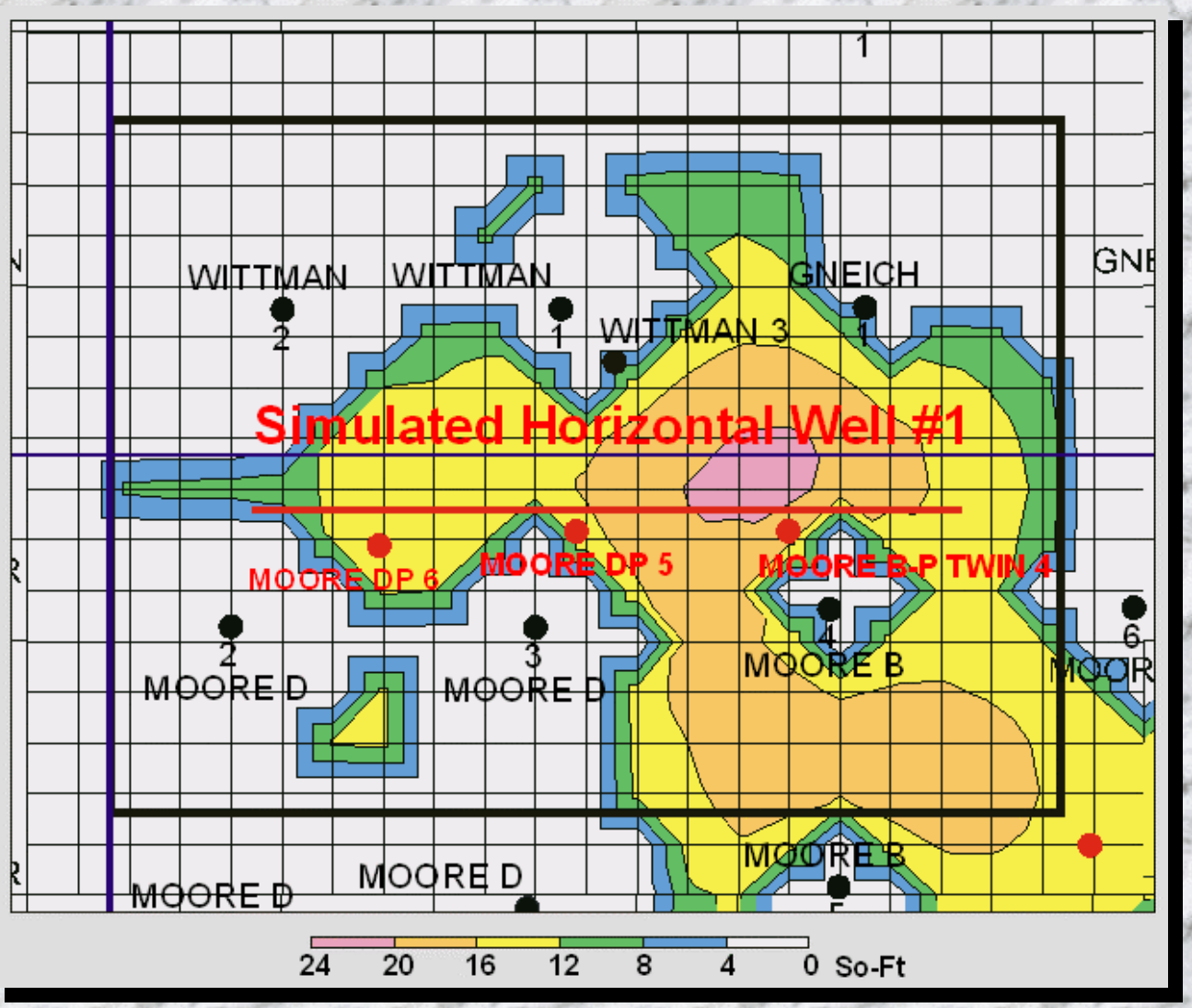
Mississippian of Kansas Horizontal Well Technology

- Reservoir Characterization
  - Mississippian of southeast Saskatchewan
- Cost-Effective Screening Tools
  - “Quick-Look” Volumetric” Calculations
    - OOIP
    - ROIP and low recovery efficiency
  - Field --> Lease Level
- Reservoir Simulation
  - PfEFFER
    - Pre-Processor
    - Post-Processor
  - BOAST VHS
  - Field --> Lease --> Grid Cell Level
- Mixed Results

Wieland West Field, Hodgeman County Kansas.



Schaben Field:
Horizontal Well Simulation



Technology Transfer: Traditional

- Short Courses (PTTC)
  - PfEFFER, BOAST 3, Internet, Petrophysics
- Publications
  - 30 Publications & Numerous Presentations
- Data
  - Production, Well Data & Logs
    - Automatic Updating Using Relational Databases
- Products
  - Maps, X-Sections, Core Descriptions, etc.
- Technology Transfer
- http://www.kgs.ukans.edu/Class2/index.html

Technology Transfer

Data & Products

DPA Home Page | Kansas DPA Home | Site Map | Help

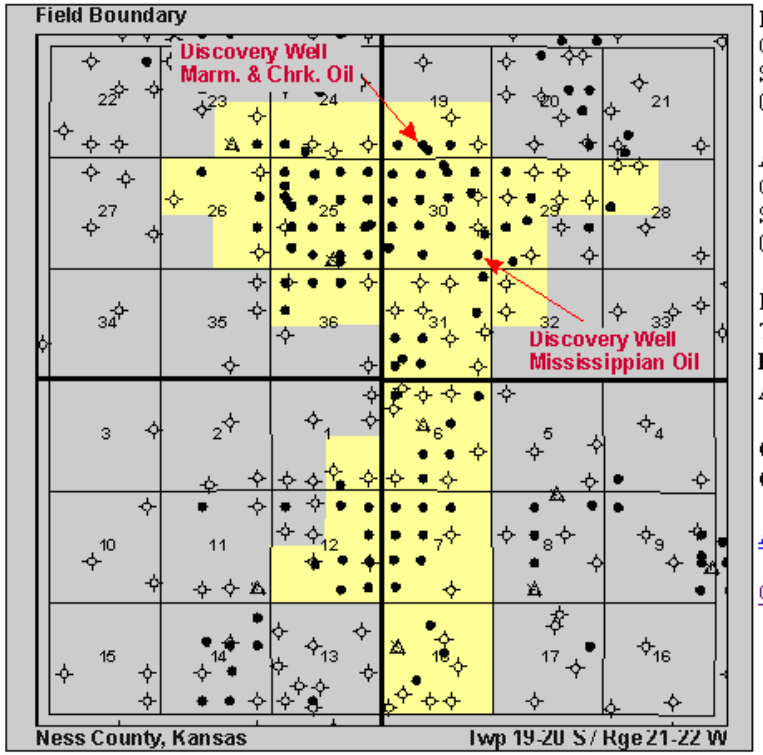
General | Geology | Geophysics | Reservoir | Wells

Field Site Map

Play: Lower Mississippian
Basin: Anadarko
County: Ness County

Schaben Field

You can explore the Schaben Field by clicking on the blue topic buttons to the left.
Use the Schaben Site Map to learn what resources are available for the Schaben Field.



Discovery Well
Cities Service Oil Company, #1 Moore 'B'
SE SE 30-T19S-R21W
09/04/63, Mississippian Oil, 4494' RTD

American Warrior, #1 Wittman, 'OWWO'
Champlin Petroleum, #1 Wittman
SE SW, 19-T19S-R21W
06/20/91, Marmaton & Cherokee, 4407' RTD

Field Size: 8,880 acres
Total Wells: 90
Productive Wells: 65
Abandoned Wells: 25

Cumulative Oil: 10,416,796 bbls as of 7/1/96
Cumulative Gas: 112,395 mcf as of 7/1/96

Annual Field Production Data

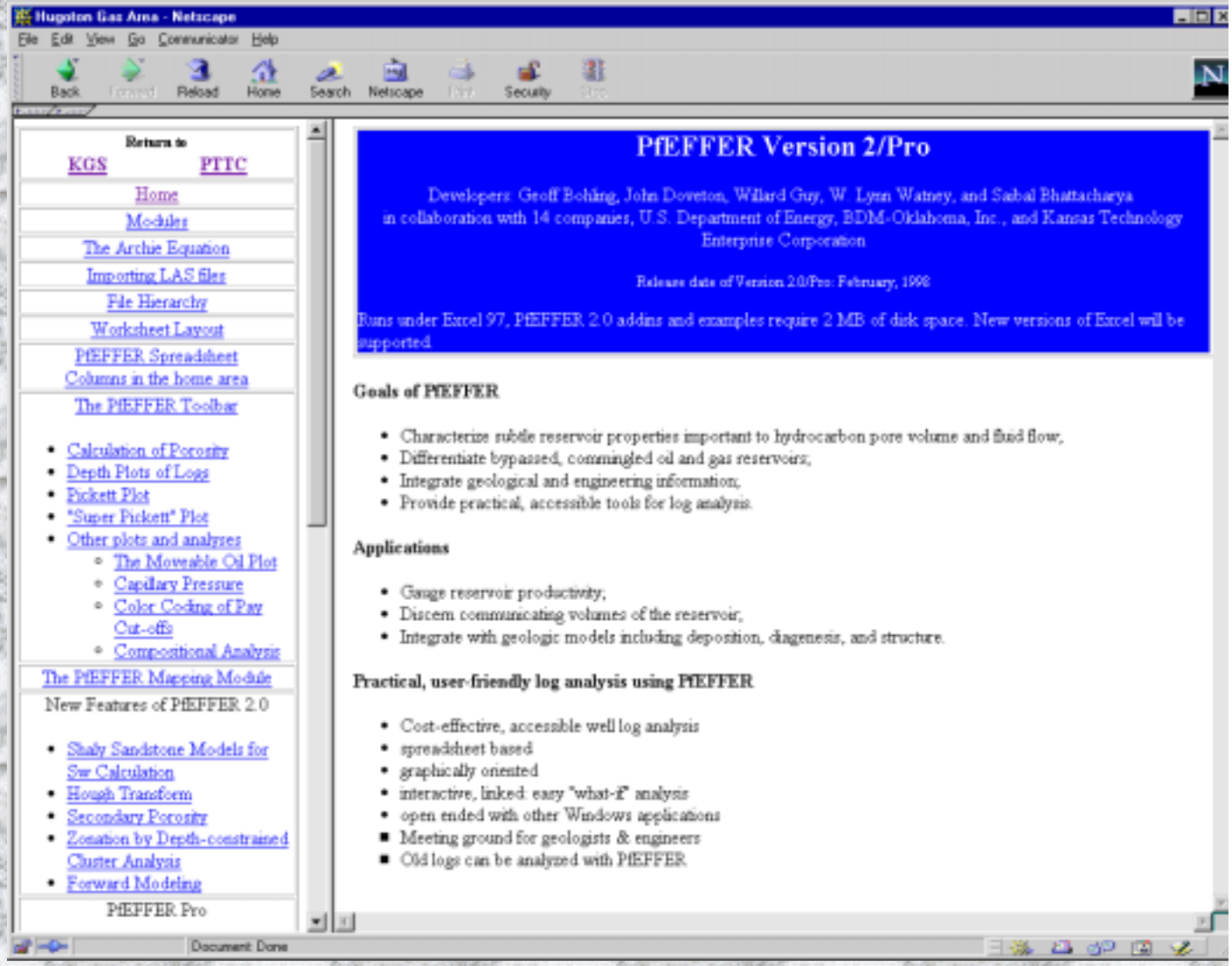
Class 2 Project Page also has info on the Schaben field.

Kansas Geological Survey, Digital Petroleum Atlas
Send comments and/or suggestions to webadmin@kgs.ukans.edu
Updated Oct. 27, 1997
URL = http://crude2.kgs.ukans.edu/DPA/Schaben/schabenMain.html

http://www.kgs.ukans.edu/DPA/Schaben/schabenMain.html

Technology Transfer

Online Courses



http://www.kgs.ukans.edu/General/Tutorial/pfeffer/

Future Products

- Improved Online Courses
  - Distance Learning
  - PTTC
  - University of Kansas Continuing Education
- Complete Revised Reservoir Simulation
- Develop Online Petrophysical Atlas
- Complete Manuscripts and Final Report

Conclusions

- Need for Cost-Effective Advanced Technologies Focused on the Small Independent
  - PC Based
  - Commonly Available Programs
- Need for Online Technology Transfer
  - Data and Results
  - Technology
  - Distance Learning
- Large Mature Resource + Low Recovery Factors + Appropriate Technology = **LARGE BENEFIT**